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Application of Graphic Multivariate Techniques In The Policy Sciences .

By

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TABLE OF CONTENTS

i

LIST OF TABLES

ii

LIST OF ILLUSTRATIONS

Figures

I. INTRODUCTION

The object of this paper is to represent multivariate data graphically. Using graphical means for communicating or explaining phenomena is as old as man himself, as the following examples illustrate: 1) Every person who has traveled in a foreign country where he could not communicate in the native language has probably resorted to drawing pictures to express his ideas or needs. 2) The pictures that have been discovered in caves and tombs have revealed numerous facts about the lives and social conditions of their creators. 3) If you have ever gone to a carpenter or machinist to have something built and have given him a complete set of instructions, nine times out of ten he will say, "Draw me a picture." In summary, people are accustomed to communicating with graphics.

The graphics program selected for this research is the face drawing program of H. Chernoff. The graphic representation of this method is a face with eyes, nose, mouth, ears and eyebrows which change when the variables which are being measured change. This is done by representing a point in k-dimensional space, (k is a scalar which defines the number of points) and changing its position according to changes in variables.

The purpose for graphical representation of multivariate data is to enhance the ability of the analyst to detect and comprehend important phenomena, serve as a mnemonic device for remembering major conclusions, communicate major conclusions to others, and provide a means for doing complex and relatively accurate calculations informally.[1] The use of a face enhances the utility of graphics techniques in accomplishing these goals by drawing on the observer's culturalization process that teaches him to recognize and respond to changes in facial expressions. It assumes that the human eye

1

functions more like an analog computer than like a digital computer. An analog computer uses continuous input whereas a digital computer reads, records and reads again in a step by step procedure. The analyst when analyzing the data is looking for clusters and not even distribution. It is precisely the clustering that lends graphics its power as an analytic tool. In the face drawing program, multivariate data that have similar properties will also be represented by similar faces. These similar clusters are called, for simplicity, families.

The subject of this analysis is Soviet foreign policy in Sub-Saharan Africa. Information has been collected which measures amounts, levels, and frequencies of Soviet activities with lesser developed countries (LDC's). Section II presents the method of data selection, examination and storage on a quick access device. Necessary modifications and transformations of the data are also discussed.

The data file was still large and some decisions had to be made about how to reduce the number of variables, without removing any important ones. Because of this last criterion, factor analysis techniques were not used. Factor analysis would have indicated, for example, that this group of variables is highly correlated, and only one of the variables or their combined factor score should be used. What is needed is a system or methodology that is more concerned with the quality of the relationship and not the quantity. The scalogram and event analysis techniques discussed in Section III are believed to have the property of measuring the qualitativeness as well as the quantitativeness of the relationships.

Sections IV, V and VI are concerned with the face drawing program. A step by step procedure is presented in Section IV of the methodology for making the necessary changes to the computer program in order to draw faces.

Section V presents the results of the faces that were computed for twenty-five
selected countries of Sub-Saharan Africa, and Section VI presents a discussion
of some of the faces which are being computed at other institutions.

II. SOURCES AND FILES

The information for this research project was obtained from two primary sources. The Center for Naval Analysis (CNA) provided the use of its Orchestration Project File[2], and the Air Force Data Service Center (AFDSC) provided use of the Worldwide Analytic Research Project (WARP) file.[3] The Orchestration File is a computer data base of information concerning communist aid and trade relations with 111 lesser developed countries (LDC) from 1954 to 1976. The WARP file is also a computer data base. It contains information on 195 countries and their relationships with six major powers: France, Japan, United Kingdom, Soviet Union, United States, and West Germany. Both files are presented in greater depth in Section A. Section B discusses the merging of selected elements of the two files into a file called the Sub-Saharan African File, and the necessary data transformations.

A. SOURCES OF DATA

1. Orchestration Project File

The Orchestration File is a computer adaption of Aid and Trade Activities of Communist Countries in Less Developed Areas of the Free World. The unit of analysis is the nation state, and the interval is the calendar year.

The file copy received from CNA was transferred to a 2311 disk pack and stored in SPSS[4] format in five separate files to reduce access time. The five files are: WORLD, AFRICA, ASIA, ARAB, and LATIN AMERICA. The files include data for twenty-one years (1954 to 1975) and ninety-one variables. The variables are organized in the following manner:

1. Variables one through ten (VAR001 - VAR010) are descriptive variables that identify the country by name and code and indicate the date of independence and the date of admission to the United Nations; only

post-independence data is included for each country.

2. Variables eleven through fifty-six (VAR011 - VAR056) and seventy-seven through eighty-two (VAR077 - VAR082) and eighty-six through ninety-one (VAR086 - VAR091) describe various Soviet, East European and People's Republic of China's interactions with the 111 LDC's. See Table 1 for a complete breakdown.

3. Variables fifty-seven through seventy-six (VAR057 - VAR076) are dichotomous variables which indicate whether or not that country has the property described. See Table 2 for a breakdown of these variables.

4. Variables eighty-three through eighty-five (VAR083 - VAR085) are country descriptive variables. They are:[5]

> VAR083 - Yearly Defense Expenditures
>
> VAR084 - Gross National Product
>
> VAR085 - Men in Armed Forces in Thousands

2. WARP File

WARP was designed for use by the Directorate of Plans and Evaluation Special Regional Studies Division in the Office of the Secretary of Defense.[6] Its purpose is to enable defense analysts to make various assessments of U.S. worldwide interests and associated threats on a quantitative basis. The data base includes country, regional, and worldwide variables which are related to the demographic, political, socio-economic, military, and commercial characteristics of the defense-related areas. (See Appendix A for a list of the 195 countries.)

There are four major categories of WARP Data: 1) General, 2) Money, 3) People, and 4) Trade. The data base is divided into these categories both logically (for access and use) and physically (for computer organization and storage). Appendix A includes a flow chart of the interrelationship of

5

TABLE I

BREAKDOWN OF THE ORCHESTRATION FILE

VARIABLE NAME	SOVIET	EAST EUROPEAN	PRC
Airline flights to LDC	VAR011	VAR012	
Number of economic aid agreements	VAR013	VAR014	VAR015
Number of military aid agreements	VAR016	VAR017	VAR018
Total value of military aid agreements	VAR019	VAR020	VAR021
Economic aid extensions	VAR022	VAR023	VAR024
Military aid grants and discounts	VAR025	VAR026	VAR027
Total economic aid drawings to date	VAR028	VAR029	VAR030
Yearly economic aid drawings	VAR031	VAR032	VAR033
Military personnel in LDC	VAR034	VAR034	VAR035
LDC military departing for training in the ...	VAR036	VAR037	VAR038
LDC military personnel training in the ... in December	VAR039	VAR040	VAR041
Economic aid technicians in the LDC	VAR042	VAR043	VAR044
Technical traines departing for training in the ...	VAR045	VAR046	VAR047
Technical trainees training in the ... in December	VAR048	VAR049	VAR050
Academic students departing for training in the ...	VAR051	VAR052	VAR053
Academic students training in the ... in December	VAR054	VAR055	VAR056
Imports from LDC	VAR079	VAR078	VAR077
Exports to LDC	VAR082	VAR081	VAR080
Merchant ship calls	VAR086	VAR087	VAR088
Arms deliveries	VAR089	VAR090	VAR091

6

TABLE II

TWENTY DICHOTOMOUS VARIABLES IN THE ORCHESTRATION FILE

VARIABLE NUMBER	VARIABLE NAME
VAR057	Offshore Hydrocarbon Producers
VAR058	Major Oil Producers
VAR059	Major Mineral Producers
VAR060	Distant Fishing States
VAR061	Major Fishing State Nominal Catch
VAR062	Landlocked States
VAR063	Shelf-locked States
VAR064	Narrow Shelf States
VAR065	Broad Shelf States
VAR066	Strait States
VAR067	Blue Water Navy States
VAR068	Coastal Navy States
VAR069	African States
VAR070	Asian States
VAR071	Latin American States
VAR072	Arab States
VAR073	Narrow Straits States
VAR074	Oceanic Archipelago States
VAR075	Coastal Archipelago and Distant Archipelago States
VAR076	States on Semi-enclosed Seas

7

the WARP files.

GENERAL. This category is composed of all variables which do not fit in the other categories. The bulk of GENERAL was extracted from the Cross-National Time-Series Data Archive of the Center for Comparative Political Research (CCPR), State University of New York. There are diverse social, political, and demographic characteristics collected for each of the 167 independent countries. In addition to the CCPR data, counts of treaties between countries, number of naval port calls, number of national banks, and United Nations voting consensus data are included. There are currently 69 data variables in GENERAL.

MONEY. Data related to major power interests abroad is shown by various monetary factors. Major data types include bilateral trade amounts, civil and military assistance programs, and products. There are currently 47 data variables in MONEY.

PEOPLE. This category contains a variety of information related to the number of military, civilian, and diplomatic personnel in foreign countries, foreign country population, number of immigrants, and other political-diplomatic variables descriptive of major power relations with foreign countries. There are currently 43 variables in PEOPLE.

TRADE. This category contains descriptive information related to essential U.S. foreign trade routes, and tonnage and value of commodities being traded over these international pathways. This category currently contains data related to a number of commodity types and 65 different trade routes.

SUB-CATEGORIES. Within each of the major categories, the WARP Data Base is sub-categorized to indicate the relationship of six major powers to 195 target countries. These relationships apply only to the GENERAL, MONEY

8

NOTE: DAHOMEY has been renamed BENIN
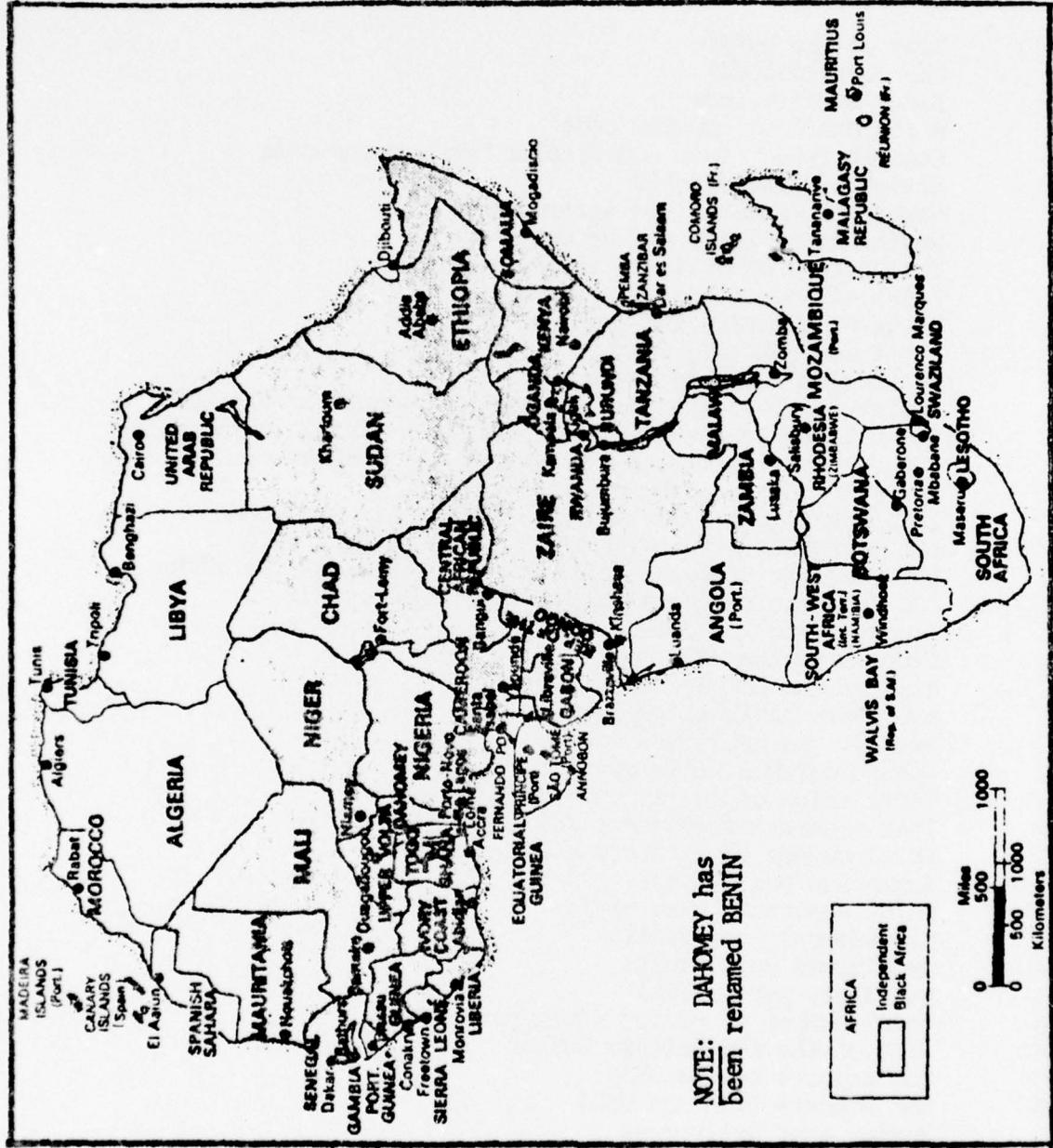
Figure 1. Map of Africa

9

TABLE III

THE 40 VARIABLES IN THE SUB-SAHARAN AFRICA FILE

Variable Number	Description
V01	Year of the entry
V02	CNA country code
V03	Banks country code
V04	World Handbook country code
V05	Case ID (year times 1,000) plus CNA country code
V06	Soviet airline flights
V07	Number of economic aid agreements
V08	Number of military aid agreements
V09	Total value of military aid agreements
V10	Value of economic aid extended
V11	Value of military aid grant or discount
V12	Total economic aid drawn
V13	Yearly economic aid drawn
V14	Soviet and East European military personnel in the LDC
V15	LDC military personnel departing for training in the USSR
V16	LDC military personnel training in the USSR as of Dec. 1976
V17	Soviet economic technicians in the LDC
V18	LDC technicians departing for training in the USSR
V19	LDC technicians training in the USSR in Dec. 1976
V20	LDC academic students departing for school in the USSR
V21	LDC academic students in the USSR in Dec. 1976
V22	Imports from the USSR
V23	Exports to the USSR
V24	Size of the LDC defense budget
V25	LDC gross national product
V26	Size of the LDC armed forces
V27	Soviet merchant ship port visits
V28	Total value of soviet arms deliveries
V29	Total number of economic aid agreements
V30	Total number of military aid agreements
V31	Submarine port visits
V32	Major combatant port visits
V33	Minesweeper port visits
V34	Amphibious port visits
V35	Auxillary port visits
V36	Total number of Soviet naval port visits
V37	Size of the LDC defense budget
V38	LDC exports to the USSR
V39	LDC imports from the USSR
V40	Soviet arms deliveries

and PEOPLE categories since the TRADE category represents only U.S. involvement. The data is organized in country-pair relationships.

B. SUB-SAHARAN AFRICA FILE

The file used to construct the faces of Soviet foreign policy is the Sub-Saharan Africa File. It was developed from the Orchestration and WARP files and consists of the twenty-five African countries shown in Figure 1. Like the Orchestration File, the unit of analysis is the nation state, and the interval is the calendar year. The period of the file is from 1963 through 1975. To be a candidate, a country had to be in Sub-Saharan Africa, independent by 1963, and underdeveloped.

1. Missing Values for Variables

The Orchestration File assigns a value of 99999 to missing entries. The WARP file only enters data for the years that complete data are available.[7] Therefore, when merging the two files, careful attention to each variable had to be given. For ease in handling, the method used in the Orchestration File was initially duplicated in the Sub-Saharan African File (99999 for missing values). However, missing values will produce erroneous results in the present FACES program. Four methods were selected to provide solutions for missing values and are presented in their precedence order.[8]

a. If the variable selected has missing values and is recorded in both files, and one file has an entry for the missing value, and the entries which are present correlate; then the entry from the other file is to be read into the missing value entry.

b. If the missing value is an end point and does not satisfy the first criteria, then exponential smoothing method is to be used to compute the missing value. The advantage of exponential smoothing is that it assumes the adjacent value is the best indicator as to the magnitude of change of the

11

missing value. It computes the geometric mean and a scalar multiplier which is most influenced by the adjacent variable.

c. If one data point is missing and it is not an end point, compute the missing value by averaging the entry before and after.

d. If more than one data point is missing, compute the missing values by the least squares technique.

2. Data Transformation

Some modification (normalization) of the data is necessary to produce the best results.[9] To use the data as they were collected might produce misleading results. For example, a maximum number of port visits by any country for any year is 60 and the mean value is 3.1. Observation of the data in its present form could be an indication that it is not very difficult to be an average country because such a country has to receive only three port visits per year. In reality it is the first few port visits that are the most difficult to achieve. What is required to properly analyze port visits is the mathematical property of port visits that will put the mean in the center of the distribution and the extremes equal opposite distances from the mean. Therefore it can be said that the distribution of port visits is not normal. A normal function would produce a bell-shaped curve when all the data points are plotted, with mean in the center of the curve. Figures 2 and 3 illustrate these distributions.
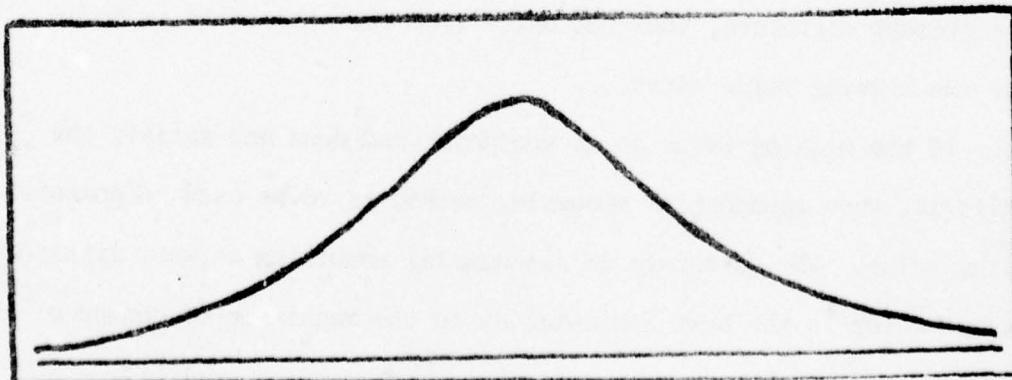
Figure 2   Normal Distribution Curve

12
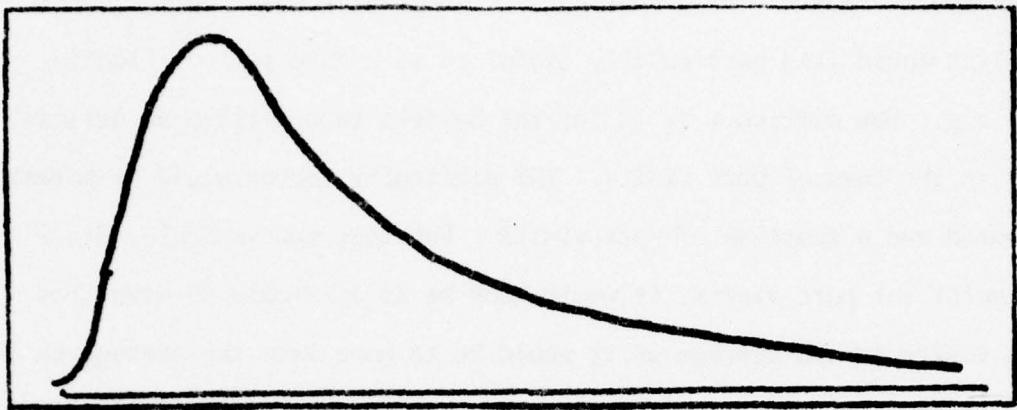
Figure 3   Distribution Curve for Port Visits

Another and more readily available indication of distribution other than normal is found in examining the skewness and kurtosis.[10]   Skewness measures deviations from symmetry.   It is the third moment and will take the value of zero when the distribution is a completely symmetric bell-shaped curve.   A value less than +3 and greater than -3 is desirable.   Positive values indicate the data is clustered more to the left of the mean with the extreme values off to the right.   Negative values indicate just the opposite condition.   In the port visits example, the skewness is 4.395.

Kurtosis is the measure of the peakedness or flatness of the curve. A value of zero indicates normal distribution.   Positive values indicate the distribution is peaked with negative values indicating flatness.   A value less than +5 and greater than -5 is desired.   Kurtosis is the fourth moment.   The kurtosis for the example is 20.560.

Experience and/or intuition tells the analyst that port visits are important and just because the data have a skewness and kurtosis that indicate peakedness and uneven distribution does not imply that visits are not important.   But to use the data statistically, one should examine them

13

to determine if they have a property that is normally distributed. What the analyst would find particularly useful in this case is a difficulty factor, e.g., how difficult it is for the Soviets to penetrate an African country in the form of port visits. The difficulty factor would be normally distributed and a function of port visits. For this new variable, difficulty factor for port visits, it would then be as difficult to move from no port visits to the average as it would be to move from the average to the maximum. Plotting the values for the new variable, difficulty factor for port visits, would produce a bell-shaped curve. For port visits the difficulty factor is assumed to be equal to the fourth root of the number of port visits for a country per year. Taking the fourth root for each element in that variable would produce a transformed variable that is approximately normally distributed with a skewness of 2.839 and a kurtosis of 0.411. Another explanation of the same data would be: a country moving from two port visits to three is much more significant an indicator of Soviet penetration than another country moving from forty-four to forty-five. A change from two to three is as significant as a change from forty-four to fifty-seven in the untransformed data.

Table 4 is a breakdown of the seventeen variables (indicating their skewness and kurtosis) used in the FACES program and, when appropriate, their transformed values.

TABLE IV

CONDESCRIPTIVES

Variable	Name	Kurtosis	Skewness	Function	Adjusted Kurtosis	Adjusted Skewness
V09	Military Aid Extended	42.586	6.313	$\sqrt[4]{V09}$	10.467	3.343
V10	Economic Aid Extended	76.824	8.107	$\sqrt[4]{V10}$	7.013	2.734
V11	Military Grants and Discounts	85.208	8.978	$\sqrt[4]{V11}$	19.847	4.442
V13	Yearly Economic Aid Drawn	86.898	8.054	$\sqrt[4]{V13}$	-0.276	0.888
V14	Soviet Military in LDC	51.706	6.602	$\sqrt[4]{V14}$	1.024	1.488
V15	LDC Military Training in USSR	30.035	5.093	$\sqrt[4]{V15}$	3.271	2.166
V17	Soviet Economic Technicians in LDC	10.379	2.982	$\sqrt[4]{V17}$	-1.133	0.388
V18	LDC Technicians Training in USSR	42.453	6.095	$\sqrt[4]{V18}$	4.036	2.409
V21	LDC Academic Students in USSR	1.606	1.362	V21	1.606	1.362
V22	LDC Imports from USSR	32.808	5.052	$\sqrt[4]{V22}$	-0.437	0.703
V23	LDC Exports to USSR	13.965	3.351	$\sqrt{V23}$	1.787	1.427
V24	Size LDC Defense Budget	38.768	6.003	$\sqrt[4]{V24}$	4.864	1.858
V25	Size LDC Gross National Product	18.245	3.802	$\sqrt{V25}$	4.206	1.767
V26	Size LDC Armed Forces	35.935	5.735	$\sqrt[4]{V26}$	3.997	1.669
V29	Total number Economic Aid Agreements	4.675	2.009	V29	4.675	2.009
V30	Total number Military Aid Agreements	5.169	2.311	V30	5.169	2.311
V36	Total number Soviet Naval Port Visits	20.560	4.395	$\sqrt[4]{V36}$	6.411	1.263

15

III. SELECTING THE VARIABLES

Three methods of analysis were used for exploratory research to
select the variable to be used in the FACES program. The three methods
were Guttman scaling, WEIS (World Event/Interaction Survey) system, and
trend analysis. They will be presented in the next three sections
along with their results.

A. GUTTMAN SCALING

Guttman scaling is a statistical technique which examines the under-
lying operating patterns which possibly connect three or more items
(in this study, ten items) to determine if the interrelationships of
those items meet several special properties which define a Guttman scale.[11]
The two most important properties are unidimensionality and cumulative-
ness. Unidimensionality requires that the variables must measure
movement towards or away from the same single objective. In this
study, the objective is Soviet penetration into Africa. Cumulativeness
implies that the variable can be scaled by the degree of difficulty
that a LDC has in achieving each variable. In this study, cumulative-
ness implies how difficult it was for the Soviets to establish them-
selves in Africa through certain specific activities, such as placing
Soviet military personnel in the country.

To analyze the results and to determine whether the scale is valid,
four statistics are produced, i.e., the coefficient of reproducibility
(C_R), the minimum marginal reproducibility (M_{MR}), the percent improve-
ment (I_t), and the coefficient of scalability (C_S). The two most
important statistics and the minimum values required to have a valid
scale are $C_R = 0.90$, $C_S = 0.60$. Figure 4 shows the results of scaling

16

ten variables and will be used in the explanation of the statistics.

A case consists of ten variables for one country for one year. In Figure 4 the figures in the right column labeled "Total" indicate the number of cases that passed the test to achieve the scale value listed in the left hand column labeled "Scale." The values in the variable column indicate the number of cases that passed and failed each item for the scale value indicated. The variable which was the most difficult for the Soviets to achieve is the variable placed in the column farthest to the left; the degree of difficulty decreases as one reads from left to right. The country which was most deeply penetrated by the Soviets is ten on the scale. The amount of Soviet penetration decreases as one reads from the top to the bottom of the scale.

The coefficient of reproducibility is equal to one minus the total number of errors (an error is an incorrect response for an item for a particular scale value), divided by the total number of responses:

$$C_R = 1 - (\text{total errors/total responses})$$
$$= 1 - (126/2720)$$
$$= 0.9537$$

The minimum marginal reproducibility is the minimum coefficient of reproducibility that could have occurred for the scale given the division points used and the number of responses passing and failing each item. It is equal to the sum of the maximum marginals for each variable divided by the total number of respondents. In Figure 4 at the bottom of the matrix are the values "SUMS," "PCTS" and "ERRORS." In the row labeled "SUMS" are two values for each variable; the larger of the two is the maximum marginal for that variable:

17

$$M_{MR} = (269 + 267 + 262 + 234 + 225 + 194 +$$
$$173 + 159 + 171 + 248) / 2720$$
$$= 2202 / 2720$$
$$= 0.8096$$

The percent improvement is the difference between the coefficient of reproducibility and the minimum marginal reproducibility:

$$I_\% = C_R - M_{MR}$$
$$= 0.9573 - 0.8096$$
$$= 0.1441$$

The final statistic is the coefficent of scalability. It is equal to the percent improvement divided by one minus the minimum marginal reproducibility:

$$C_S = I_\% / (1 - M_{MR})$$
$$= 0.1441 / (1 - 0.8096)$$
$$= 0.7568$$

The results of scaling the ten variables produce a pattern of Soviet relationships with the twenty-five countries in the Sub-Saharan File. Eight of these variables were checked against the files on Africa and World with similar results. As a result of the scaling, the first ten variables were selected for the FACES program (see Table 5 for these variables). The WEIS system provided the next variable.

18

Figure 4

Guttman Scale of Sub-Saharan Africa 1963 through 1975

ITEM..	V11		V05		V10		V18		V15		V14		V30		V29		V17		V21		TOTAL
RESP.	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	
S 10	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	1
9	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	1
8	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
7	14	1	13	1	13	2	4	2	0	15	0	15	0	15	0	15	0	15	1	14	15
6	39	0	37	0	36	2	26	13	11	28	2	37	0	39	4	35	1	38	0	39	39
5	23	0	23	0	23	0	20	3	23	0	3	20	0	23	0	23	0	23	0	23	23
4	10	0	10	0	9	1	9	1	10	0	9	1	2	8	1	9	0	10	0	10	10
3	68	0	68	0	68	0	64	4	68	0	67	1	60	8	11	57	2	66	0	68	68
2	35	0	35	0	35	0	33	2	35	0	35	0	23	2	19	16	20	15	0	35	35
1	55	0	55	0	55	0	55	0	55	0	55	0	55	0	55	0	55	0	0	55	55
0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23
SUMS	269	3	267	5	262	10	234	38	225	47	194	78	173	99	113	159	101	171	248	24	272
PCTS	99	1	98	2	96	4	86	14	83	17	71	29	64	36	42	58	37	63	91	9	126
EFRCRS	0	2	1	4	0	6	4	23	0	10	5	2	2	10	16	16	23	0	0	1	126

325 CASES WERE PROCESSED
53 (OR 16.3 PCT) WERE MISSING

STATISTICS..

COEFFICIENT OF REPRODUCIBILITY = 0.9537
MINIMUM MARGINAL REPRODUCIBILITY = 0.8096
PERCENT IMPROVEMENT = 0.1441
COEFFICIENT OF SCALABILITY = 0.7568

TABLE V

THE 10 GUTTMAN SCALED VARIABLES

Scale Value	Variable	Variable Name
10	V11	Soviet Military Grant or Discount
9	V09	Total Value of Military Aid Agreement
8	V10	Soviet Economic Aid Extended
7	V18	LDC Economic Technicians Training in the USSR
6	V15	LDC Military Training in USSR
5	V14	Soviet Military Personnel in the LDC
4	V30	Military Aid Agreements
3	V29	Economic Aid Agreement
2	V17	Soviet Economic Technicians in LDC
1	V21	Academic Students in USSR

B. WEIS SYSTEM

The WEIS System is a machine readable coded content analysis of the
New York Times. Each entry includes the actor (the country directing
the activity), the target (country at which the activity is directed),
and arena (area in which the event takes place), and an event code
(ranks the activities ordinally from one to twenty-two with sub-cate-
gories). The entry also contains a brief summary of the article.[12]

An events search of the WEIS System indicated a pattern of Soviet
foreign policy activities, including port visits by Soviet Naval units,
in three Sub-Saharan African countries. These results were similar to
the results obtained in the Guttman scaling. Because the three patterns

20

were similar, further tests were made applying Guttman scaling to port visits. The results indicated that port visits could be scaled and consequently, port visits were included in the list of variables for the FACES program.

The number of events coded for Africa is very low and not considered to be a reflection of actual activity in Africa. Instead the low number of events probably reflects a lack of reporting on Africa by the New York Times, or reflects the selection criteria of the person doing the coding. Although the WEIS system did not contain enough information to be used statistically for this project, it did serve as an indicator of some of the more important events, and it could effectively be used to search for patterns in other areas of the world.

The six remaining variables were chosen through trend analysis.

C. TREND ANALYSIS

Figures 5 and 6 are graphs of Soviet imports and exports with the world's 111 LDC's and the 42 LDC's in the Africa File. Figure 5 indicates that in trade with the LDC's, worldwide, the balance of trade is in favor of the Soviet Union. But, Figure 6 reveals that in 1959, 1960, 1963, and 1965 the balance of trade between the Soviets and Africa was in favor of the African states.

Another interesting facet of Soviet trade with all LDC's (Figure 5) is the indication that from 1958 to 1964 there was a stable trading pattern. From 1964 to 1969 there appeared a noticeable increase in the balance of trade in favor of the Soviet Union, but indications in 1969 were that there was a decrease in Soviet exports paralleled by an increase in imports. The 1970 through 1974 period reflected a sharp increase in both imports and exports by the Soviet Union.

21
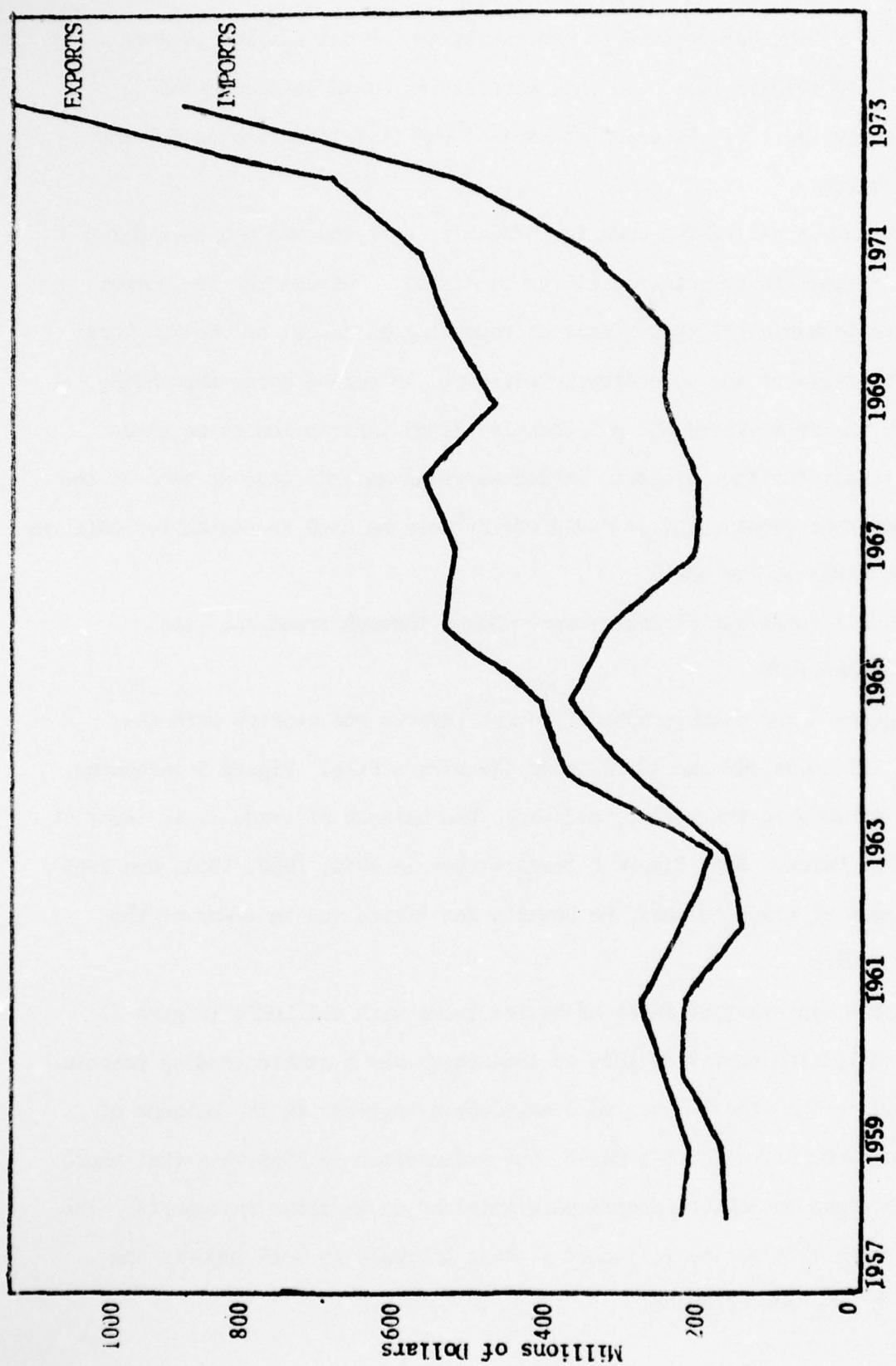
Figure 5

Soviet Trade with 111 Lesser Developed Countries 1958 through 1973

22
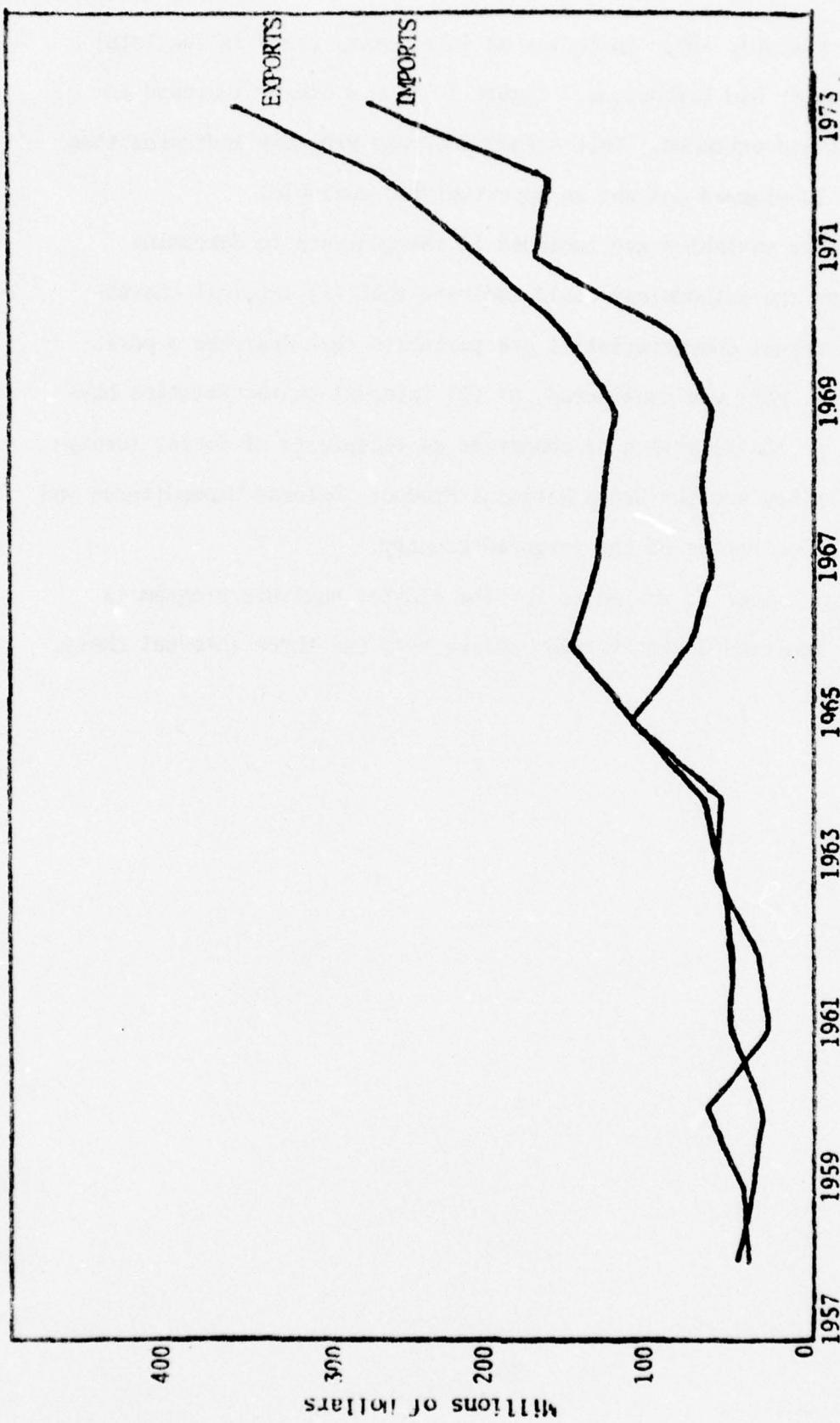
Figure 6

Soviet Trade with 42 African Countries 1958 through 1973

Another variable which indicates an interesting trend is the Total Value of Economic Aid Extensions. Figure 7 shows a steady increase in the amount of aid extended. This steady increase probably indicates that economic aid is planned and not an opportunistic variable.

Three other variables are included in the analysis to determine whether or not the methodology could indicate that (1) internal characteristics (internal characteristics are variables that describe a particular LDC, i.e. GNP) are considered, or (2) internal characteristics have an influence on the selection of countries as recipients of Soviet foreign policy acts. They are the Gross National Product, Defense Expenditures and Size of the Armed Forces of the targeted country.

The total number of variables for the cluster analysis program is seventeen -- fourteen Soviet foreign policy acts and three internal characteristics.
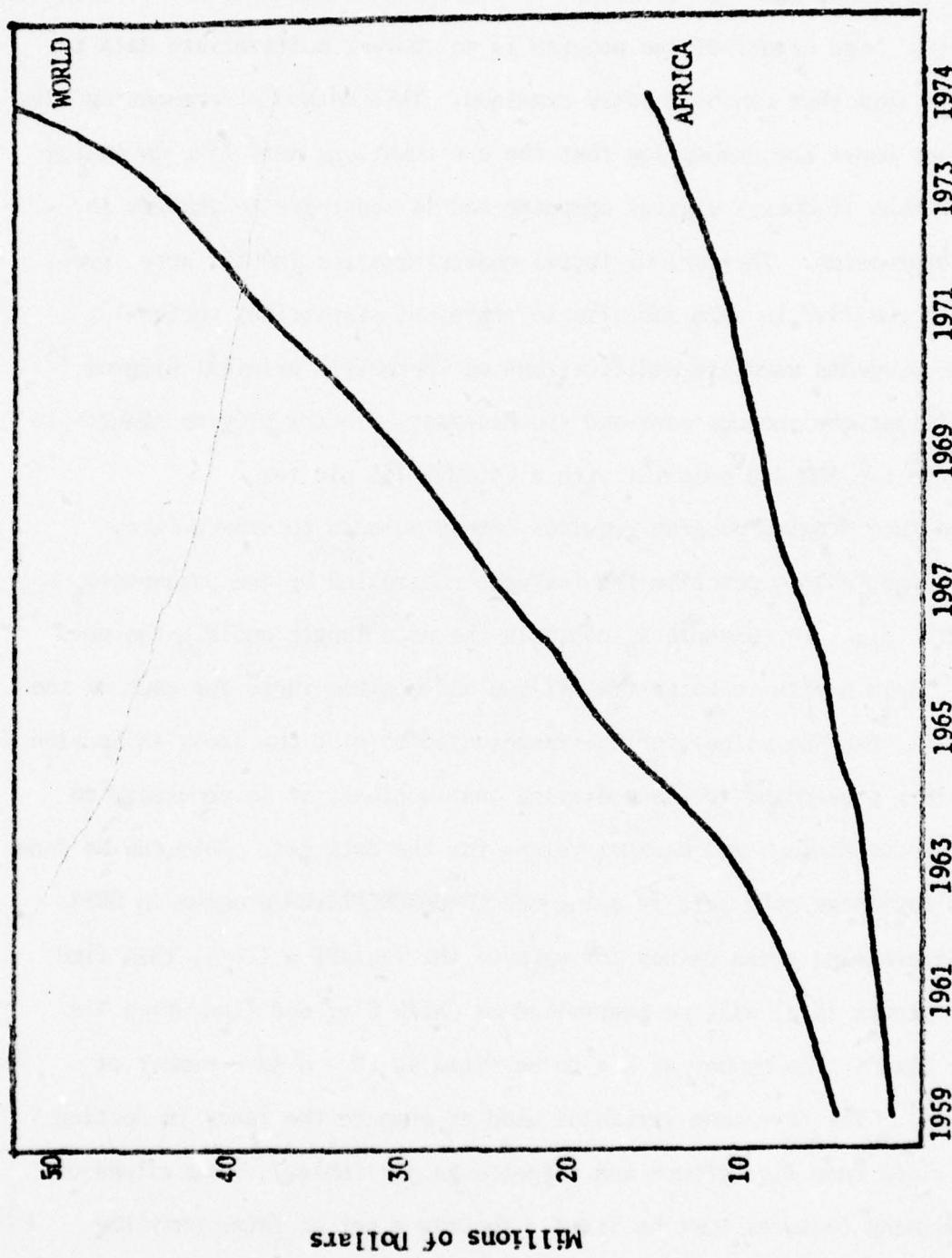
Figure 7

Total Soviet Economic Aid Drawn 1959 through 1974

25

IV.   REPRESENTATION OF MULTIVARIATE DATA
WITH COMPUTER DRAWN FACES

The FACES program was developed by Professor Herman Chernoff at Stanford University. The object of the program is to convert multivariate data to a graphic form that can be readily examined. This method of presenting data was chosen under the assumption that the eye functions more like an analog computer than it does a digital computer and is sensitive to changes in facial expression. The various facial characteristics (mouth, nose, eyes, etc.) are modified in form and size to represent statistical vectors.

The programs used are modifications of Chernoff's original program.[13] The modifications include ears and the necessary plotter program changes to operate on the IBM 360 computer with a CALCOMP 765 plotter.

The face drawing program requires twenty numbers to draw a face. Figure 8 and Table 6 describe the features controlled by the parameters X_1, X_2,....X_{20}. For example X_6 controls the nose length and X_{20} the nose width. Table 6 also contains the maximum and minimum range for each of the twenty X's, and the values for the ranges used to plot the faces in Section V.

Before proceeding to the modifying instructions, it is necessary to determine the minimum and maximum values for the data set. This can be done quickly for large data sets by using the CONDESCRIPTIVES program in SPSS. After determining these values for each of the variables (Z's), then find which features (X's) will be controlled by which Z's, and find which X's will be fixed. The number of X's to be fixed is 20 - d (d = number of variables). The seventeen variables used to compute the faces in Section V were divided into five groups and targeted as per Table 7. The values of the remaining features must be fixed. To draw a set of faces only the computer input instructions require modification.

26
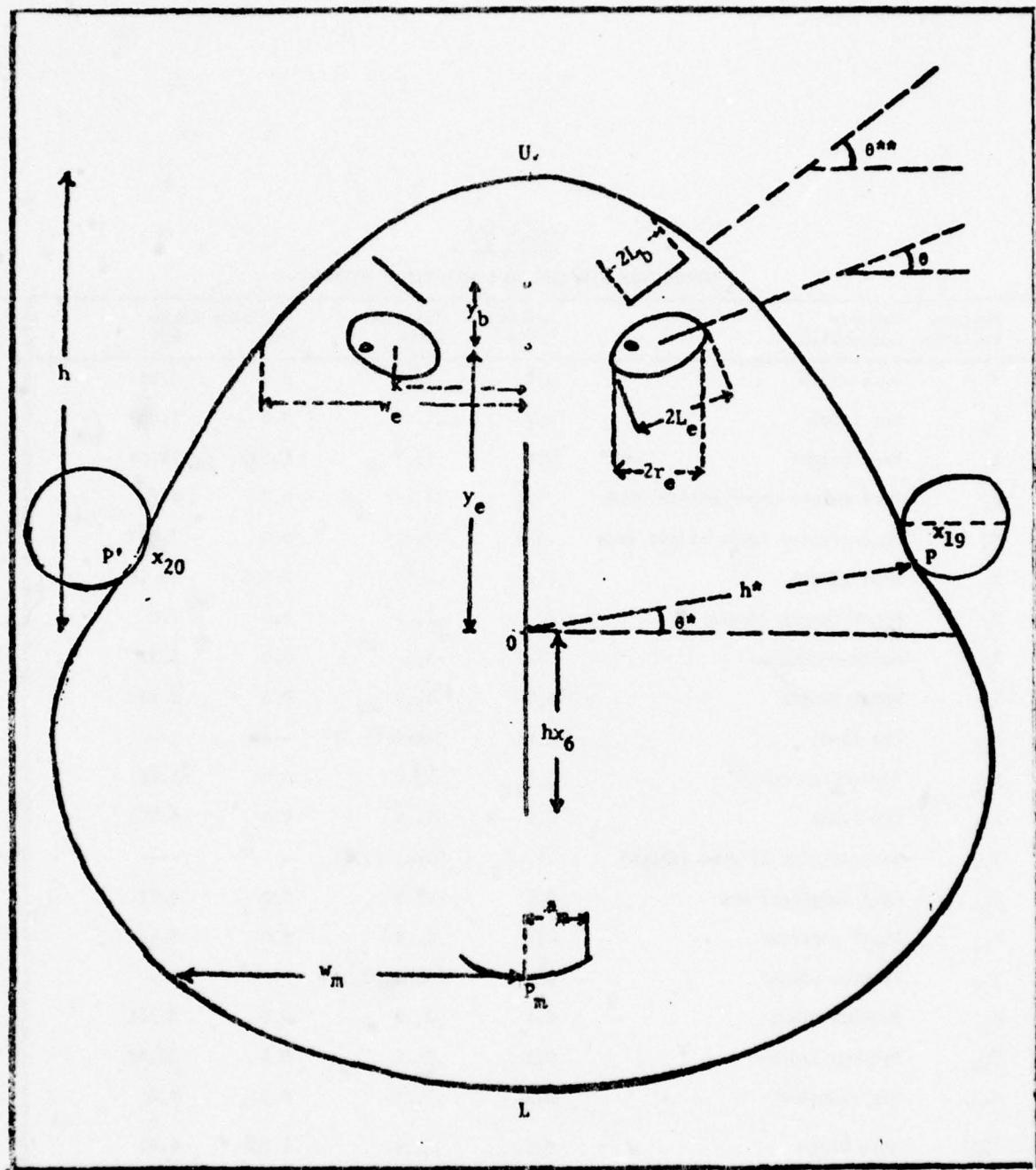
Figure 8

Chernoff Face with Ears

TABLE VI

PARAMETERS FOR THE 20 STATISTICAL VECTORS

Feature Variable	Feature Controlled	Feature Range	Selected Range	Variance Range Min.	Max.
X_1	Face width	0,1	.1,.7	0.0	5.64
X_2	Ear level	0,1	.1,.7	0.0	1.000
X_3	Face height	0,1	.1,.7	5.500	18.04
X_4	Eccentricty upper elipse face	.5,2	.7,1.7	0.0	4.73
X_5	Eccentricity lower elipse face	.5,2	.7,1.7	0.0	2.829
X_6	Nose length	0,1	.2,.9	3.005	16.52
X_7	Mouth center (level)	0,1	.2,.8	0.0	7.0
X_8	Mouth curvature	-5.5	-5,5	0.0	5.32
X_9	Mouth length	0,1	.2,.9	0.0	4.23
X_{10}	Eye level	0,1	Fixed (0.3)	----	----
X_{11}	Eye separation	0,1	.2,.8	0.0	5.84
X_{12}	Eye slant	0,4	.1,.8	0.0	4.873
X_{13}	Eccentricity of eyes (shape)	.4,.8	Fixed (0.6)	----	----
X_{14}	Half length of eye	0,1	.4,.8	0.0	4.71
X_{15}	Pupil position	0,1	.2,.9	0.0	5.51
X_{16}	Eyebrow height	0,1	Fixed (0.5)	----	----
X_{17}	Eyebrow slant	0,1	.2,.6	0.0	3.761
X_{18}	Eyebrow length	0,1	.4,.8	0.0	31.64
X_{19}	Ear diameter	0,1	.1,.5	0.0	9.0
X_{20}	Nose width	0,1	.2,.8	1.00	4.41

TABLE VII

VARIABLE ASSOCIATION

VARIABLE NAMES	FEATURE NUMBER	FEATURE DESCRIPTION
PEOPLE CONTACTS		
Academic Students	X_2	Ear level
LDC Technicians Departing	X_{17}	Eyebrow slant
Soviet Economic Technicians in the LDC	X_{18}	Eyebrow length
MILITARY PERSONNEL (MIL PERS) CONTACTS		
Soviet Mil Pers in the LDC	X_1	Face width
LDC Mil Pers in the Soviet Union	X_4	Upper elipse of face
Port Visits by Soviet Naval Units	X_5	Lower elipse of face
ECONOMIC CONTACTS		
Economic Agreements	X_{19}	Ear diameter
Imports	X_{11}	Eye separation
Exports	X_{12}	Eye slant
Economic Aid Extended	X_{15}	Pupil position
Yearly Economic Aid Drawings	X_{14}	Half-length of eye
MILITARY AID CONTACTS		
Military Aid Agreements	X_7	Mouth level
Military Aid Extensions	X_8	Mouth curve
Military Grants and Discounts	X_9	Mouth length
LDC CHARACTERISTICS		
Gross National Product	X_3	Face height
Size of Defense Budget	X_6	Nose length
Size of Armed Forces	X_{20}	Nose width
FIXED FEATURES		
Fixed	X_{10}	Eye level
Fixed	X_{13}	Eye shape
Fixed	X_{16}	Eyebrow height

V. OTHER APPLICATIONS OF THE FACES PROGRAM

Chernoff published his first article on graphic representation of multivariant data using faces in the Journal of the American Statistical Association in 1971.[14] Following the publication of this article, a number of people working in various fields used this program. Some of these efforts are mentioned below.

Lawrence A. Bruckner of the Los Alamos Scientific Laboratory of the University of California, working under the auspices of USERDA (United States Energy Research and Development Administration), is studying the performance of ten offshore oil groups.[15]

In 1973 Chernoff applied his methodology to a geological experiment in which he used faces to represent the mineral contents from fifty-three equally spaced samples from a 4500 foot core drilled into a Colorado mountain.[16]

Probably the most innovative follower of Chernoff's work is Bud Goode of Bud Goode's Sports Computer in Studio City, California. Goode has established his own sports consulting service for major league sports and provides his services to several broadcasting networks who use his faces to predict the results of televized football games. A significant contribution which Goode made to the faces concept was his use of a full character (football player) to represent the data rather than using just the faces.

Goode's latest project is representing trends in U.S. Supreme Court decisions. Future work will include modeling of Congress and of an entire newspaper. He believes that computerized statistical graphical methods will provide useful insight in many areas as long as the messages are simple,

direct and can be quickly grasped. [17]

Another pioneer in computer graphics is Dr. Carol M. Newton of UCLA Health Sciences Computing Facility. Dr. Newton and Jerry Johnson, senior systems programmer for the facility, have developed an interactive graphic (on-line) program in which the analyst works from a video display screen and experiments with his data. [18]

In addition to the Chernoff faces, Newton and Johnson have developed on-line programs that perform statistical analysis with polygons, bar graphs, arrows and scattergrams. The work has been used in heart research, study of respiratory disease and comparative anthropology.

Johns Hopkins University has begun a number of projects using Chernoff faces. These projects are the result of research done primarily by William H. Huggins, former chairman of the Electrical Engineering Department, in his research on iconic communications. His primary work is in support of a project with the United States Public Health Service Hospital to develop a method of psychiatric screening. [19]

Dr. David L. Huff of the University of Texas is the most recent person to use the Chernoff faces. He plans to use the methodology to develop urban regional indicators that measure quality of life.

VI. A FOREIGN POLICY APPLICATION OF THE FACES PROGRAM

This section presents the results of the FACE drawing program as applied to the twenty-five country Sub-Saharan African File. Section A takes a look at the long-term trends from 1964 through 1975. The faces represent a four-year average for the country they represent. Section B looks at the changes in the faces in twenty of the countries from 1968 through 1975. Five of the countries which had minimal contact with the Soviet Union were omitted.

A. SOVIET POLICY, 1964 THROUGH 1975.

Figure 9 is a representation of the three families (groupings based on similarity of features) of Soviet foreign policy acts into which the twenty-five countries are grouped. Group one of Figure 9 is constructed using the maximum values for the fourteen foreign policy acts selected for this experiment. The three internal values represent the average for all twenty-five countries. Similarly, group two is constructed with the average values and group three with the minimum values. As with group one, the internal variables were constructed with the mean values.
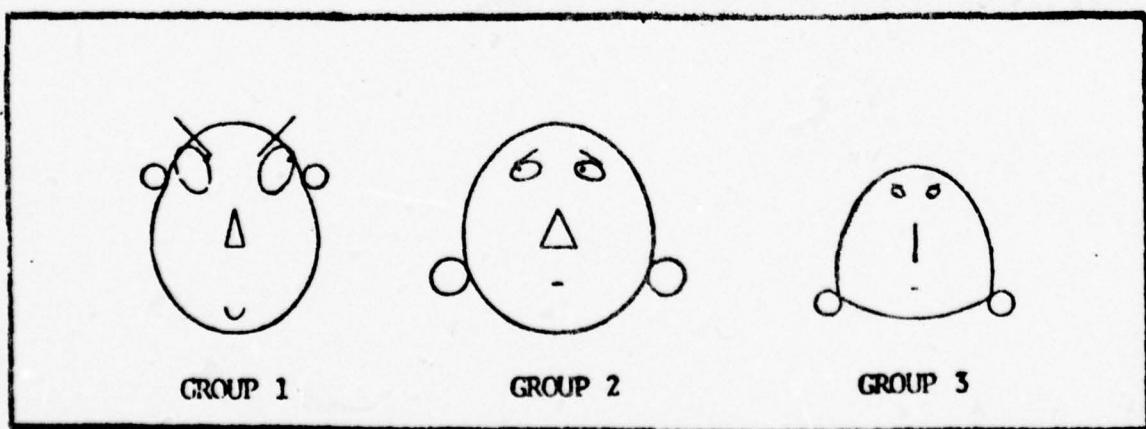

Figure 9 The Three Family Groups of Soviet Foreign Policy Acts.

The validity of using intentional targeting, rather than random targeting, was assessed by a sample test of the data. This assessment was accomplished by giving two sets of twenty-five faces each, one set with the variables intentionally targeted and the other randomly targeted, to two independent subjects and asking each of them to arrange each of the two sets into three families. The results of the two tests were then compared and the findings were that fewer grouping errors occurred in the intentionally targeted sets and the groupings compared with the three faces in Figure 9. Figure 10, which represents Soviet relations with the twenty-five Sub-Saharan African countries from 1964 through 1968, illustrates the data used in this test. It was therefore decided to use the intentional targeting method over random targeting and the faces in this chapter were drawn as previously stated in Section IV.

A comparison of Figures 10, 11 and 12 revealed some interesting facts concerning Soviet foreign policy: 1) an increase in Soviet efforts over the whole area, rather than in selected areas, was indicated by the tendency of the faces to fall into Group Two; 2) Sino-Soviet competition in Africa was supported by two look-alike faces moving from Group One to Group Two in all three figures. A check of the data verified that these two countries (Uganda and Tanzania) had been recipients of aid from the PRC and the USSR.

The expressions of the three countries (faces with worried looks) in Group One of Figure 10 (Peoples Republic of the Congo, Uganda, and Tanzania), are influenced by the economic contacts and people contacts shown in Table 7 (Section IV). The ear diameter and pupil position indicate a willingness for economic involvement on the part of the Soviets, but the eye and eyebrow indicate that little follow-through of initial effort is apparant. The pupil position and ear height of Kenya in Group Three of Figures 10 - 12 provide an

33
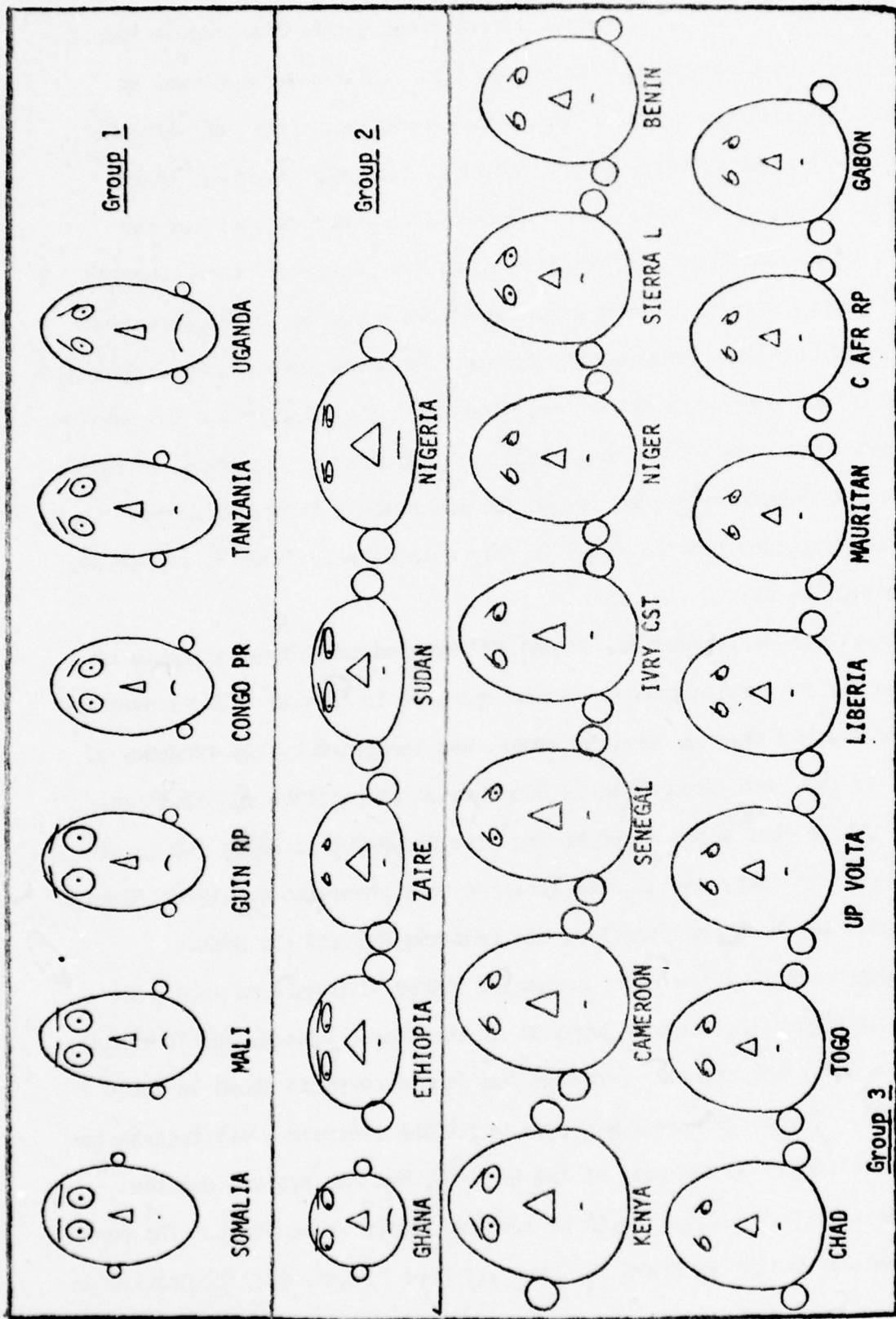
Figure 10. Soviet Foreign Policy Faces 1964 Through 1967
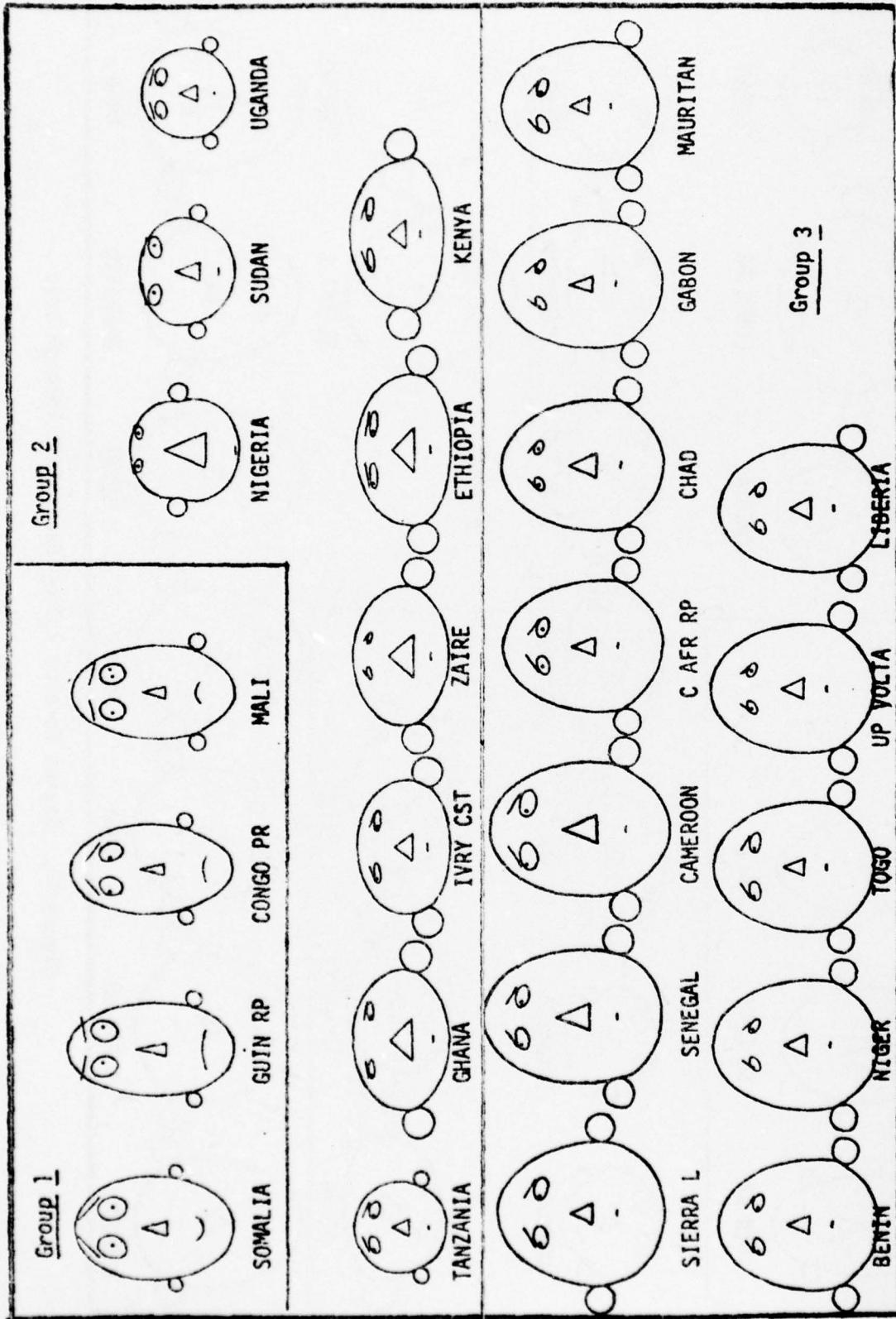
Figure 11. Soviet Foreign Policy Faces 1968 Through 1971

Group 1

GUIN RP   SOMALIA   MALI

UGANDA   TANZANIA   GHANA   ETHIOPIA

Group 2

NIGERIA   CONGO PR   SUDAN

IVRY CST   CAMEROON   BENIN

Group 3

SIERRA L   SENEGAL

ZAIRE

KENYA   UP VOLTA   TOGO   NIGER   GABON   MAURITAN   CHAD

LIBERIA   C AFR RP
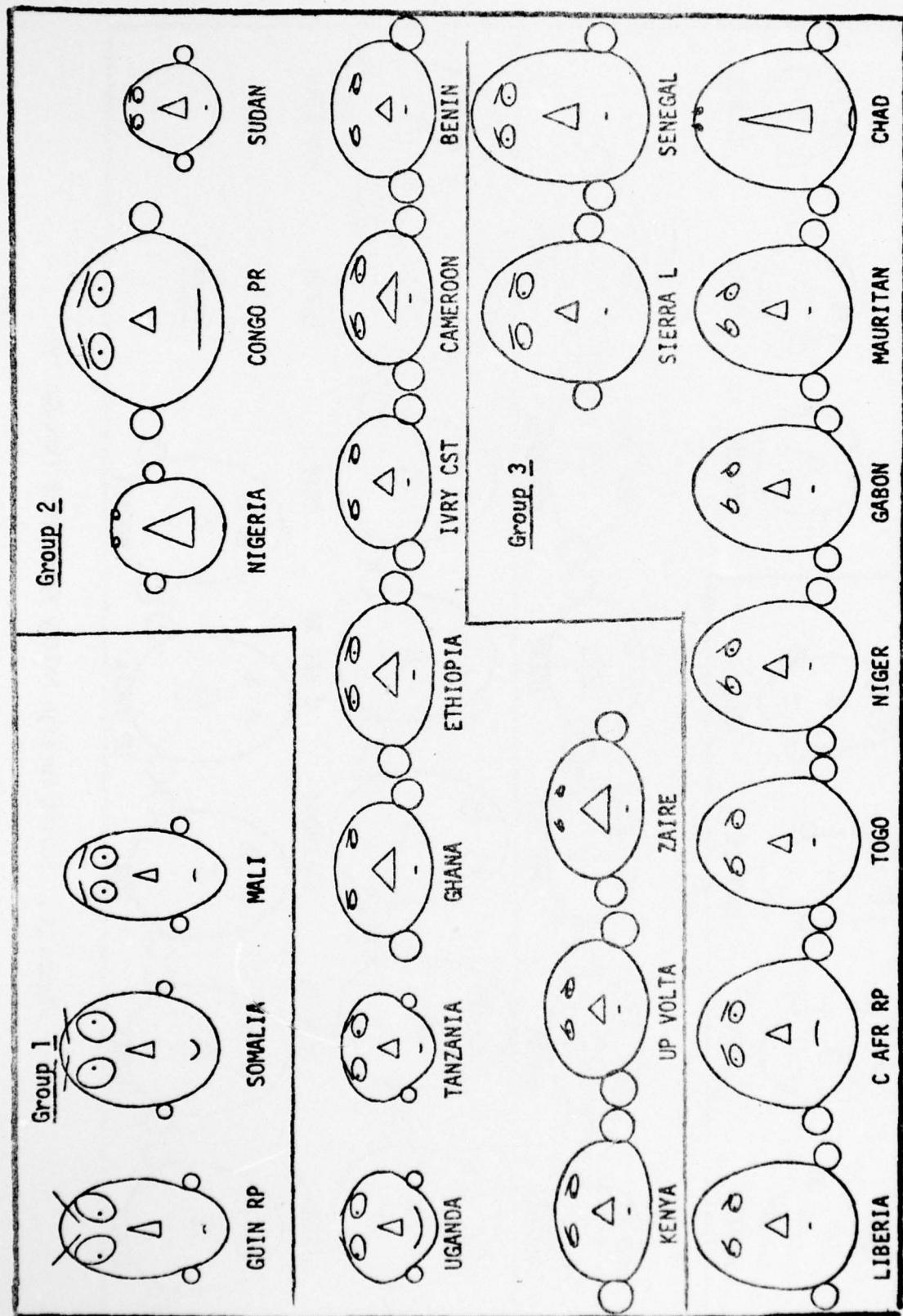
Figure 12. Soviet Foreign Policy Faces 1971 Through 1975

36

early economic indicator. The country showing the most upward mobility between Figures 10 and 11 is Sudan. But in Figure 12 the change in face width, indicates that the number of Soivet military personnel decreased in the final time period.

In summary, Figures 10, 11 and 12 appear to indicate the existence of a stable policy overall in the region. Some evidence of the Sino-Soviet competition is apparent with an overall loss for the Soviets. The three countries in Group One in Figure 12 are in Group One in Figure 10 and 11 also.

B. SELECTED YEARLY FACES FROM 1968 THROUGH 1975

Figures 13 through 19 represent the faces of Soviet foreign policy in twenty countries on a yearly basis from 1968 through 1975. Each country is represented by two rows of faces, reading from left to right for the years 1968 through 1975. There are three countries per figure except for Figure 14 which represents only two countries, Nigeria and the Peoples Republic of the Congo. Figure 13 presents the faces with the highest values and Figure 19 presents the faces with the lowest values for the set.

Figure 13 shows a Soviet pattern present in Guinea, Somalia and Mali Republic. In each of the three sets of faces, the length of the eyebrow (number of Soviet economic technicians in the country) is followed by a change in the angle of the eyebrow (number of LDC technicians departing for training in the USSR) then by a change in pupil position (economic aid extended). Another indicator is in the relationship between the angle of the eyebrows and the eccentricity of the forehead (LDC technicians and military personnel departing for the Soviet Union). Until the angle of the left eyebrow reaches

37
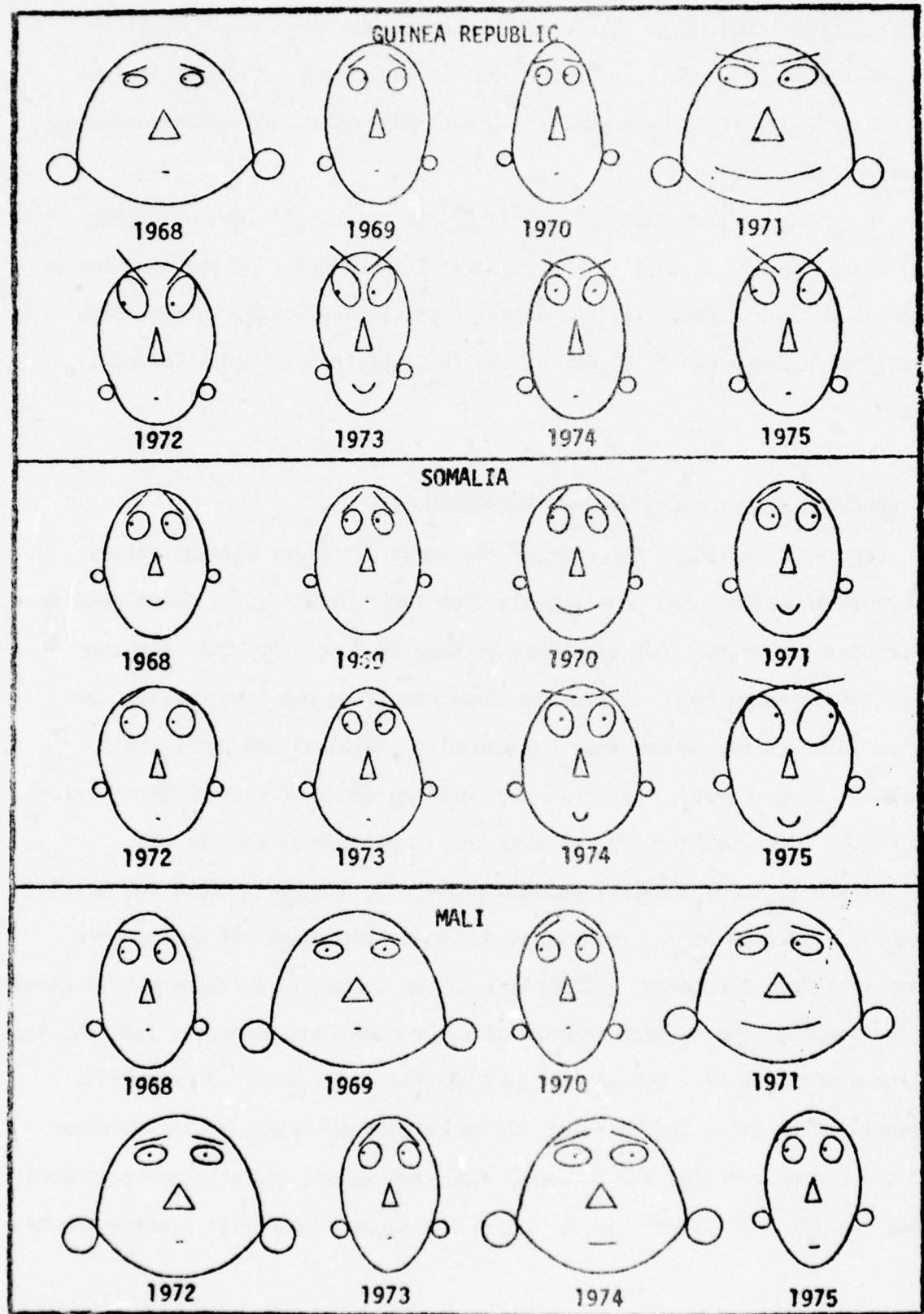
Figure 13. Changing Faces 1968 Through 1975

38

a horizontal plane in clockwise rotation, it appears to be a tangent of the eccentricity of the upper elipse of the face. A long smiling mouth (curvature is controlled by value of military aid extension--the more the happier, and mouth length is controlled by the size of grant or discount) is a relation-ship that only occurs in four countries, the three in Figure 13 and the Peoples Republic of the Congo in 1975 (Figure 14). It is also usually pre-ceded by a decrease in ear diameter (number of economic agreements) and a lowering in the height of the mouth (increase in number of military aid agreements).

Figure 14 presents two of the more interesting groups of faces, Nigeria and Peoples Republic of the Congo. Nigeria has all the early indicators, i.e., large number of students in the Soviet Union (ear height), economic aid agreements (ear diameter) several military aid agreements (as the number of aid agreements increase, the mouth level drops) and Soviet military personnel present (face width). Also noticable is the eccentricity of the chin (increasing number of port visits) for 1969, 1970 and 1975. In 1968, 1974 and 1975 the upper elipse of the face indicates substantial numbers of Nigerian military personnel departing for training in the Soviet Union. Still these faces present a strange appearance. This uniqueness is explained by the eye-brows, eyes and the nose. Economic aid and trade is low (eyes and eyebrows), GNP is high (face height, as values increase height decreases) and it has a large defense budget and large armed force (nose height and width respectively). 1971 indicates, by pupil movement, that substantial econcomic aid grant was offered, but there was no indication of acceptance.

Peoples Republic of the Congo shows an overall increasing trend toward increased Soviet contact with a slight setback in economic relations in 1973.
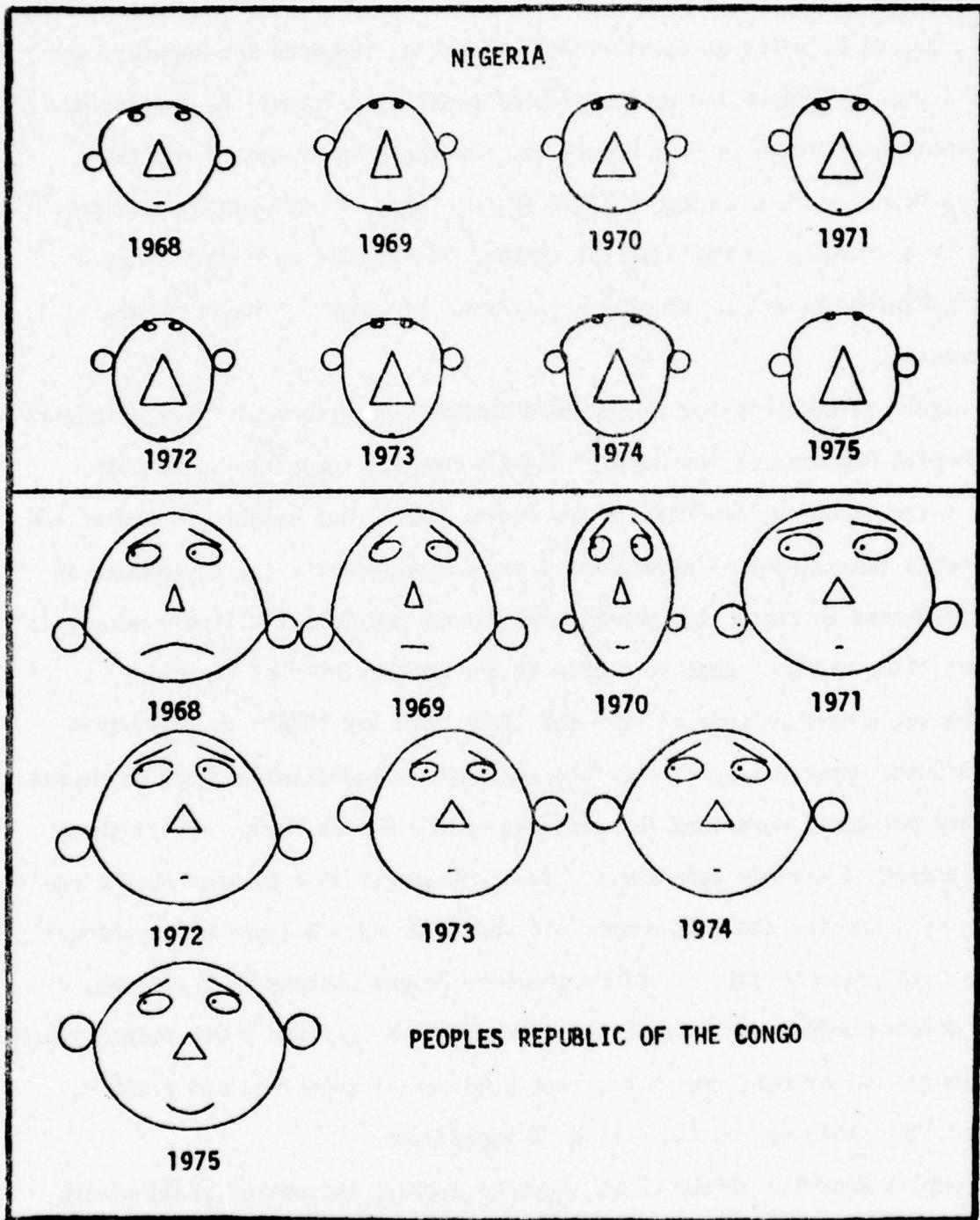
Figure 14. Changing Faces 1968 Through 1975

40

The smiling face of 1975 would be the one of most concern to an analyst as it indicates large grants and discounts as well as large military aid extensions and several port visits.

The first set of faces in Figure 15 indicates that Soviet presence in Sudan was well-established in 1968. The smile in 1968 shows a large military aid extension (mouth curvature), but no discounts (mouth length). Other 1968 indicators are large economic aid drawing (eye slant) and large number of Soviet economic technicians (eyebrow length). A large economic extension (pupils), increase in students (ear height) which reaches its height in 1970, and port visits by Soviet naval units (chin) are shown in 1969. In 1971 a turn for the worse for the Soviets begins to appear. The eyebrows start a counter-clockwise rotation followed in 1972 by a similar pattern with eye slants. In 1974 a sharp increase in the number of Soviet technicians occurs in an apparent effort to save its program in Sudan. This was followed in 1975 by a large withdrawal of Soviet military personnel.

The second set of faces in Figure 15 are those illustrating Soviet penetration in Uganda. 1970 begins a period of steady economic growth for the Soviets above the mean value for the data set. The eyebrows and eyes begin their rotations in 1970 and continue even through 1971 and 1972 when there is a decrease in the number of Soviet military personnel (face width). The period 1973 through 1975 is a time of steady gains for the Soviets in Uganda. The four features with the most significant change are: ear diameter (economic aid agreements); half length of the eye (yearly economic aid drawing); eyebrow length (increase in the number of Soviet economic technicians); and face width (increase in number of Soviet military personnel). The large smile in 1974 indicates Uganda received the most difficult of the foreign policy

41
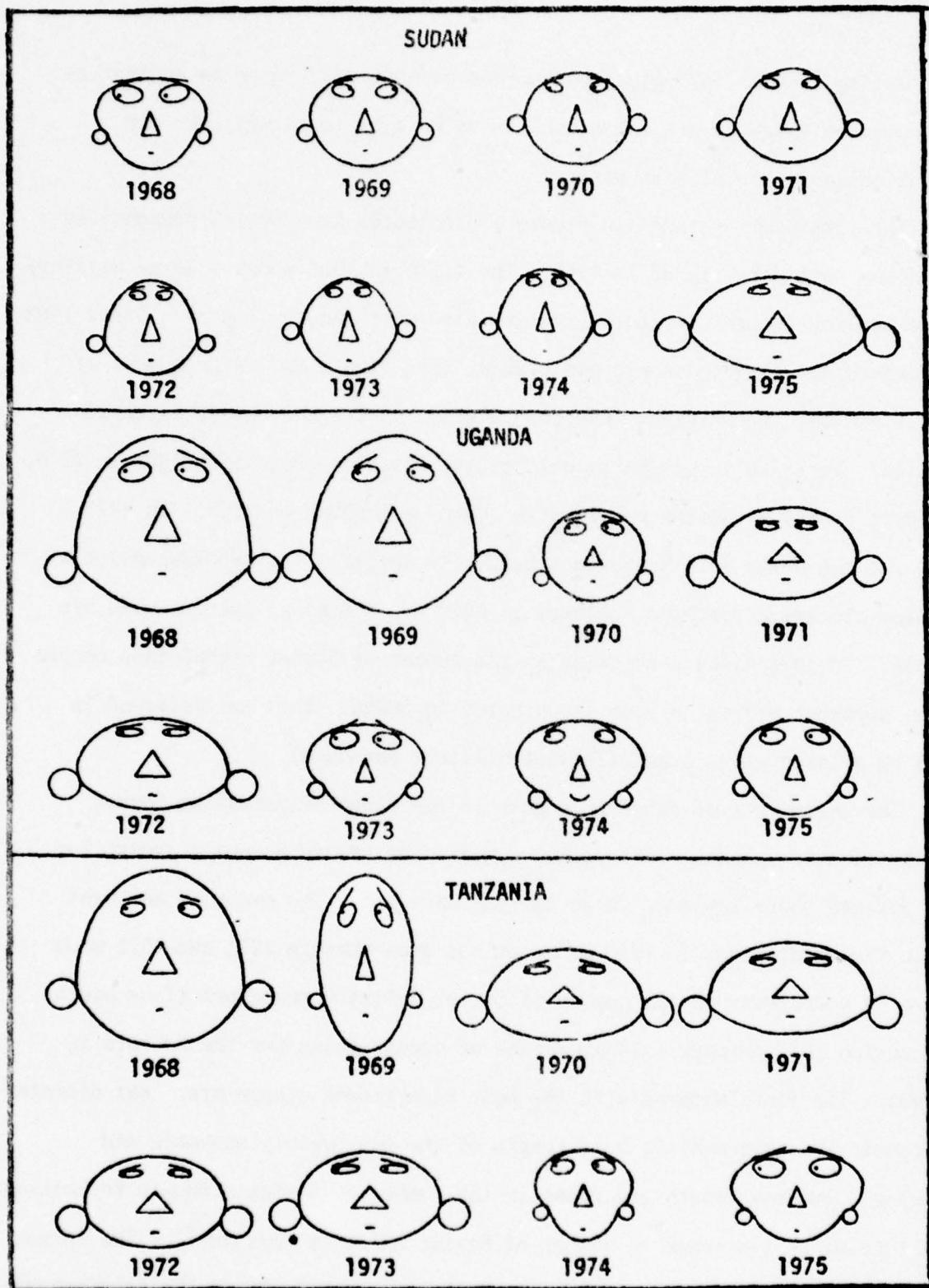
Figure 15. Changing Faces 1968 Through 1975

42

acts--a large military extension combined with a substantial grant or discount.

The final set of faces in Figure 15 illustrates Soviet penetration in Tanzania. As previously discussed in Section A of this section, Tanzania and Uganda present a similar pattern of Soviet activities. Figure 15 presents the similarity more clearly. In 1969 the upper elipse of the face shows a large number of military personnel departing for the Soviet Union which drops off again in 1970. Also indicated in 1970 is a decrease in the number of port visits. An increase in Soviet economic technicians is indicated in 1969. This increase establishes a trend for this variable that continues through 1975. A decrease in the number of Soviet military personnel is shown from 1970-1974. The Soviet face for Tanzania in 1974 is very similar to the Soviet face for Uganda in 1973. These two latter faces indicate a possible trend which can be stated roughly as follows: when relations are restored after a setback, they rapidly return to and often exceed the level of prior activity.

The next six sets of faces shown in Figures 16 and 17 all have moderate relations with the Soviet Union. Some effort of penetration is apparent in Ghana, Figure 16, through changes in ear level, eye shape, eyebrow length and the structure of the mouth. The face for 1975, however, reveals that little success has so far resulted from the efforts. The second set of faces in Figure 16, Ethiopia, shows a more favorable face each year towards the Soviets. The only noticeable change in the Ivory Coast, Figure 16, is in imports, exports and the number of naval port visits.

Cameroon, shown in Figure 17, demonstrates some activity in the eye and eyebrow. A slow increase in the number of economic technicians is paralleled by similar increase in trade and economic aid drawings. A shift
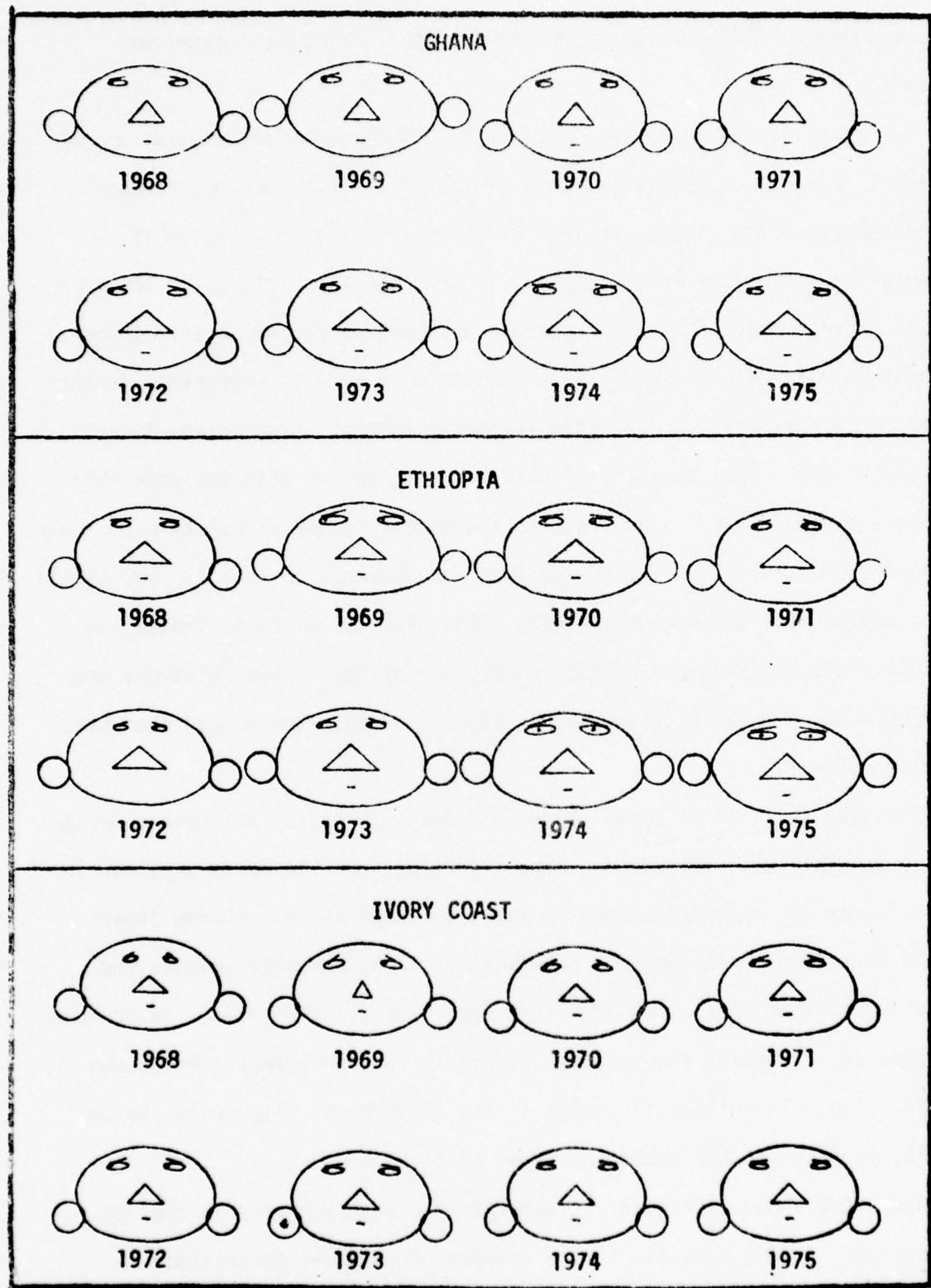
Figure 16. Changing Faces 1968 Through 1975

44
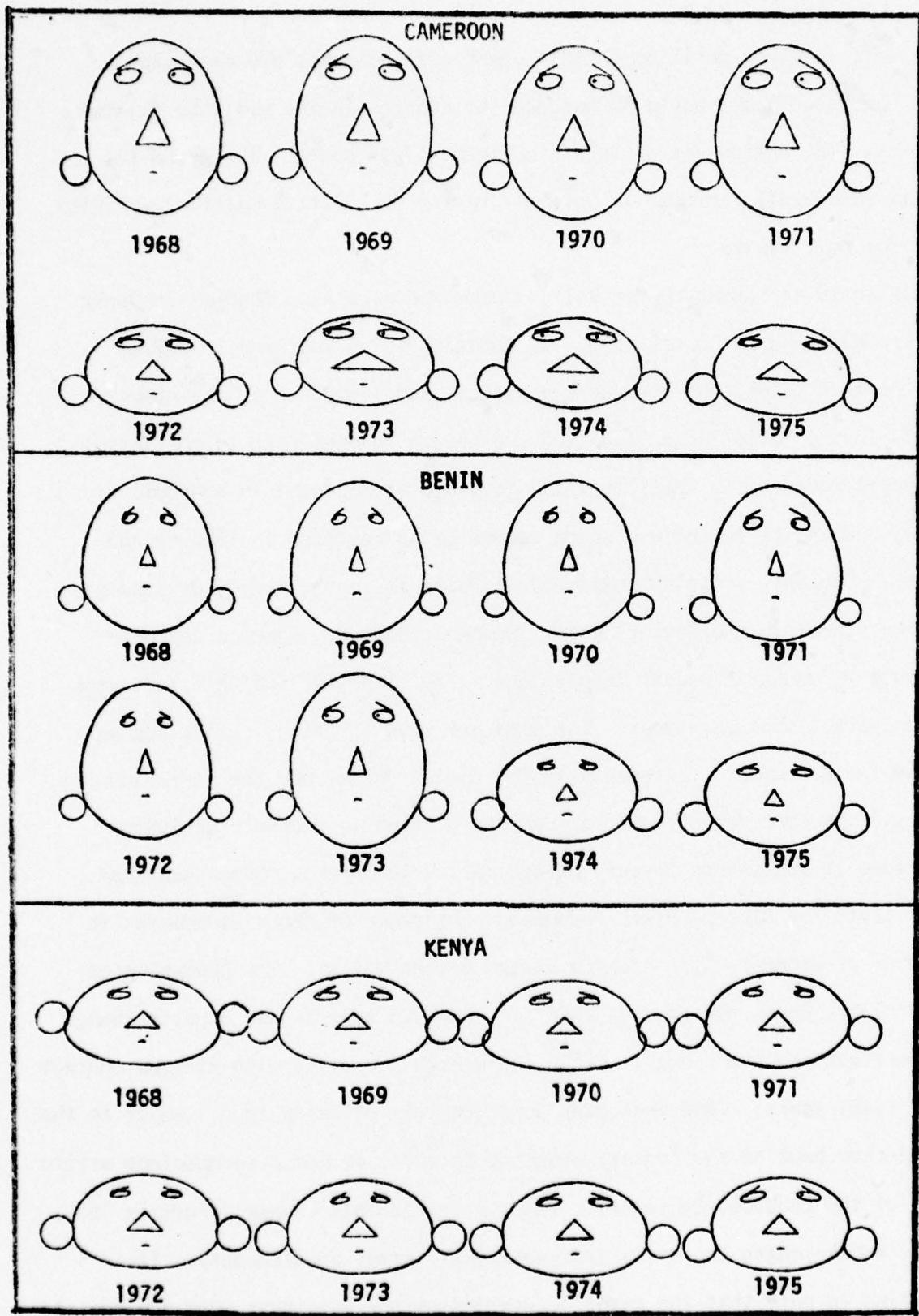
Figure 17. Changing Faces 1968 Through 1975

45

to the left in pupil position in 1974 signals an economic aid extension. Future Cameroon faces should be watched for changes in the military related variables. The bottom set of faces in Figure 17 is Kenya. The trend for Kenya is an overall decrease in Soviet activity with little military activity, except for port visits.

Figure 18 represents Upper Volta, Zaire and Senegal. Changes in Upper Volta are not apparent until 1973. In addition to an increase in GNP to above the mean level, the ears show a slight rise (increase in the number of students in the Soviet Union) and the eyes begin to open more to the Soviet view (pupil movement to the left which reflects an increase in economic aid extended and change in the eye shape caused by an increase in imports and exports). The only activity indicated in Zaire is in the number of students attending school in the Soviet Union. Senegal, however, shows a definite potential for increased Soviet involvement. The elipse of the chin indicates numerous port visits each year. The ears are slowly rising, reflecting an increase in the number of students in the Soviet Union, and the variables in and around the eyes demonstrate an increasing trend in economic activity.

Figure 19 represents Soviet foreign policy in Liberia, Gabon and Chad. The ear level for Liberia rises throughout the range of faces (increases in the number of students from Liberia in the Soviet Union). The beginning of trade activity opens the eyes in 1974 (increase in imports and exports change eye separation and eye slant). Gabon represents a country with minimum contact for all eight years. Chad indicates some economic offering (pupil shift to the left and then back to the center) starting in 1973, economic technicians arrive (length of the eyebrows increase). The most noticeable change occurs in 1975, when the mouth length increases (large military grant or discount). It is interesting to note that the grant occurs during the same year when the Soviets

46
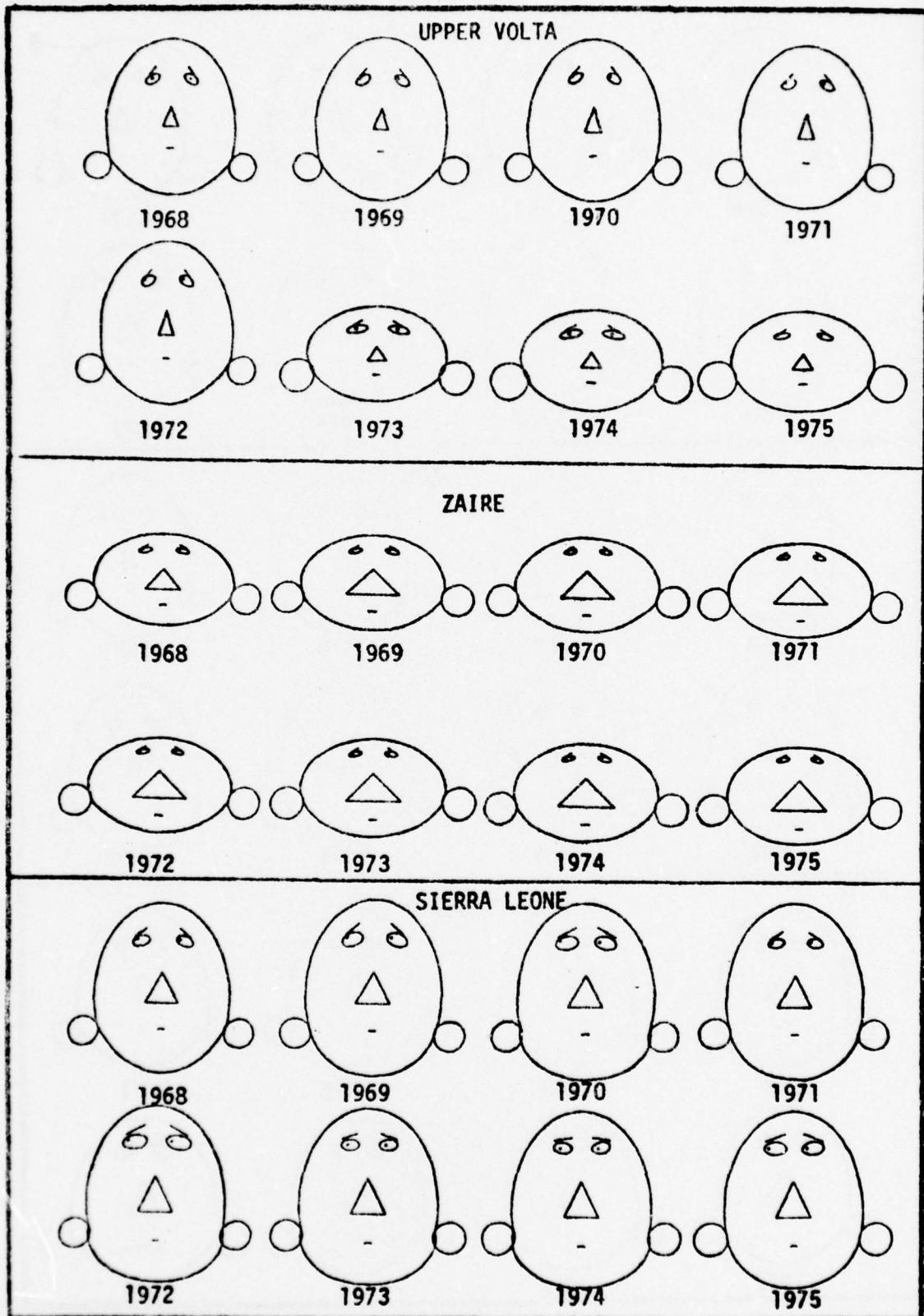
Figure 18.   Changing Faces 1968 Through 1975
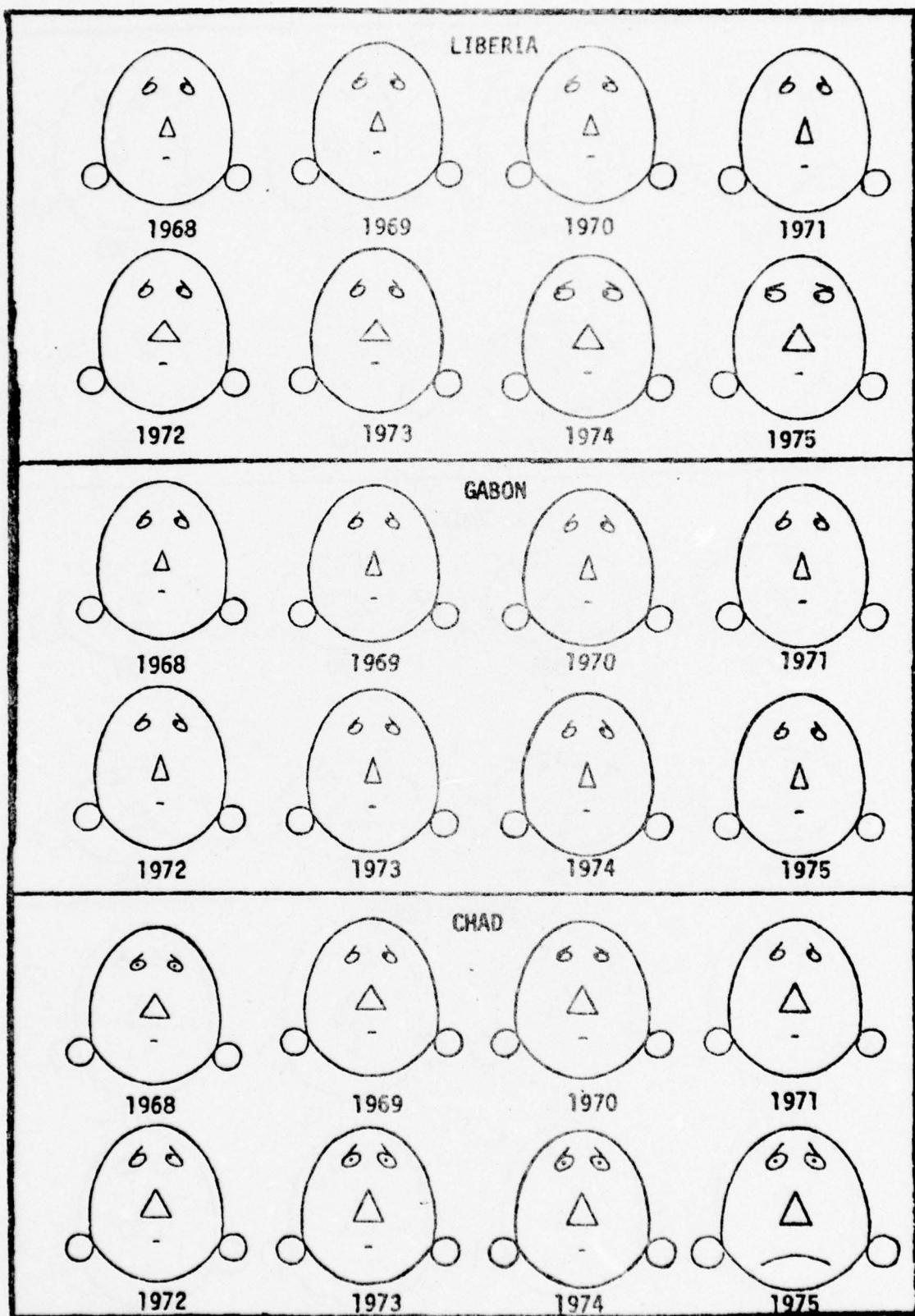
Figure 19. Changing Faces 1968 Through 1975

48

are experiencing difficulty in neighboring Sudan. Experimenting with a
larger data base could reveal possible Soviet military geographical interest
and associated patterns of penetration.

VII. CONCLUSIONS

The utility of Chernoff's faces as a diagnostic or evaluation tool demonstrates a promising approach for a first look at multivariate data. It has the advantage that in analysis of complex relations, indications can be made of patterns or clusters that are not always visible from simple correlations based on two-dimensional linear theories.

As international relations become more complex and the probability of Third World nations' influence on the course of international relations continues, a growing need emerges for real time systems to monitor, display and communicate the complex phenomena associated with international relationships. At present the majority of analyses of international relations is ex post facto. With increasing means of transportation and communication, the role of the analyst must change from an emphasis on evaluating what has already happened to an increasing responsibility to forecast, with degrees of confidence, the probable outcome of events, and to recommend alternatives in foreign policy, deployment of military units and procurement of weapons systems. These forecasts will enable decision makers to make the best selection of the alternatives available to yield desired results.

Other types of computer graphics displays can be developed to aid analysts in modeling Soviet foregin policy. As demonstrated in the FACES program, the variables can be represented by a vector with length and motion. By using three-dimensional graphic equipment, the variables could be represented by a series of elipsoids   Where $X^2/_a2 + Y^2/_b2 + Z^2/_c2$ could represent the properties of each variable and it could be rotated; the velocity of rotation

would represent the rate of change for the variable. Sets of these elipsoids could be displayed simultaneously and through time-series analysis, the analyst could visually examine the phenomena. The primary reason for this approach is that the variables are multi-dimensional and the real relationships are therefore compound multidimensional phenomena. If this technique still indicated patterns between or within the elipsoids, consideration could be given to applying the basic laws of nature for frameworks for modeling.

Computer-aided graphical display of international relations phenomena has the potential for moving international studies and analysis from an art to a science, which alllows for a rapid simplistic presentation of complex relations.

APPENDIX A

1. Abbreviations for the 195 Countries in the WARP File

COUNTRY ABBREVIATION	COUNTRY NAME
AFGHNSTN	AFGHANISTAN
AFRCA NS	AFRICA NS
AFRS-ISS	AFARS-ISSAS
ALBANIA	ALBANIA
ALGERIA	ALGERIA
ANGOLA	ANGOLA
ARGENTIN	ARGENTINA
AUSTRALI	AUSTRALIA
AUSTRIA	AUSTRIA
BAHAMAS	BAHAMAS
BAHRAIN	BAHRAIN
BARBADOS	BARBADOS
BELGUIM	BELGUIM
BELIZE	BELIZE
BENIN	BENIN
BERMUDA	BERMUDA
BHUTAN	BHUTAN
BNGLDSH	BANGLADESH
BOLIVIA	BOLIVIA
BOTSWANA	BOTSWANA
BR SOLMN	BRITISH SOLOMON
BR WI NS	BRITISH WEST INDIES NS
BRAZIL	BRAZIL
BRUENI	BRUNEI
BULGARIA	BULGARIA
BURMA	BURMA
BURUNDI	BURUNDI
C AFR RP	CENTRAL AFRICAN REPUBLIC
C VRD IS	CAPE VERDE ISLANDS
CAMBODIA	CAMBODIA
CAMEROON	CAMEROON
CANADA	CANADA
CHAD	CHAD
CHILE	CHILE
CHINA ML	CHINA MAINLAND
CHINA RP	CHINA, REPUBLIC OF
CMORO IS	COMORO ISLANDS
COLUMBIA	COLUMBIA
CONGO PR	CONGO, PEOPLES REPUBLIC
COSTA RI	COSTA RICA
CUBA	CUBA
CYPRUS	CYPRUS
CZCHSLVK	CZECHOSLOVAKIA

Country Abbreviation	Country Name
DENMARK	DENMARK
DMNCN RP	COMINICAN REPUBLIC
E GRMNY	EASTERN GERMANY
EA PC NS	EAST ASIA AND PACIFIC NS
ECUADOR	ECUADOR
EGYPT	EGYPT
EL SALVA	EL SALVADOR
EQU GUIN	EQUATORIAL GUINEA
ETHIOPIA	ETHIOPIA
EUROP NS	EUROPE NS
FAROE IS	FAROE ISLANDS
FIJI	FIJI
FINLAND	FINLAND
FLKN IS	FALKLAND ISLANDS
FR WI NS	FRENCH WEST INDIES NS
FRANCE	FRANCE
GABON	GABON
GAMBIA	GAMBIA, THE
GERMANY	GERMANY
GHANA	GHANA
GIBRLTAR	GIBRALTAR
GLB-E IS	GILBERT-ELLICE ISLANDS
GREECE	GREECE
GREENLAND	GREENLAND
GUADLUPE	GUADELOUPE
GUAM	GUAM
GUATEMAL	GUATEMALA
GUIAN FR	GUIANA, FRENCH
GUIN RP	GUINEA REPUBLIC
GUIN-BIS	GUINEA-BISSAU
GUYANA	GUYANA
HAITA	HAITI
HONDURAS	HONDURAS
HONGKONG	HONG KONG
HUNGARY	HUNGARY
ICELAND	ICELAND
INDIA	INDIA
INDONESI	INDONESIA
IRAN	IRAN
IRAQ	IRAQ
IRELAND	IRELAND
ISRAEL	ISRAEL
ITALY	ITALY
IVRY CST	IVORY COAST
JAMAICA	JAMAICA
JAPAN	JAPAN
JORDAN	JORDAN
KENYA	KENYA
KOREA	KOREA
KUWATT	KUWATT

Country Abbreviation	Country Name
LAOS	LAOS
LEBANON	LEBANON
LESOTHO	LESOTHO
LEWRD IS	LEEWARD ISLANDS
LIBERIA	LIBERIA
LIBYA	LIBYA
LUXEMBRG	LUXEMBOURG
MACAO	MACAO
MALAWI	MALAWI
MALAYSIA	MALAYSIA
MALDIVES	MALDIVES
MALI	MALI REPUBLIC
MALTA	MALTA
MARTINIQ	MARTINIQUE
MAURITAN	MAURITANIA
MAURITIU	MAURITIUS
MEXICO	MEXICO
MLGSY RP	MALAGASY REPUBLIC
MNGLN RP	MONGOLIAN REPUBLIC
MOROCCO	MOROCCO
MZMBIQUE	MOZAMBIQUE
N KOREA	NORTH KOREA
N VIETNM	NORTH VIET-NAM
NAMIBIA	NAMIBIA
NAURU	NAURU
NE SA NS	NEAR EAST AND SOUTH ASIA NS
NEPAL	NEPAL
NEW CLDN	NEW CALEDONIA
NEW HBRD	NEW HEBRIDES
NEW ZLND	NEW ZEALAND
NICARAGU	NICARAGUA
NIGER	NIGER
NIGERIA	NIGERIA
NORFOLK	NORFOLK
NORWAY	NORWAY
NTHR ANT	NETHERLANDS ANTILLES
NTHRLNDS	NETHERLANDS
OMAN	OMAN
OT AFRCA	OTHER AFRICA
OT EA PC	OTHER EAST ASIA AND PACIFIC
OT EUROPE	OTHER EUROPE
OT NE SA	OTHER NEAR EAST AND SOUTH ASIA
OT W HMP	OTHER WESTERN HEMISPHERE
PAKISTAN	PAKISTAN
PANAMA	PANAMA
PAPUA NG	PAPUA NEW GUINEA
PARAGUAY	PARAGUAY
PERU	PERU
PHLPPNS	PHILIPPINES
PN CNL Z	PANAMA CANAL ZONE

Country Abbreviation	Country Name
POLAND	POLAND
PORTUGAL	PORTUGAL
QATAR	QATAR
REUNION	REUNION
RHODESIA	RHODESIA
ROMANIA	ROMANIA
RWANDA	RWANDA
S AFRICA	SOUTH AFRICA
S VIETNM	SOUTH VIET-NAM
SAMOA AM	SAMOA, AMERICAN
SAO T PR	SAO TOME & PRINCIPE
SAUDI AR	SAUDI ARABIA
SENEGAL	SENEGAL
SEYCHLLS	SEYCHELLES
SIERRA L	SIERRA LEONE
SINGAPOR	SINGAPORE
SOMALIA	SOMALIA
SPAIN	SPAIN
SRI LANK	SRI LANKA
ST HELNA	SAINT HELENA
ST PR-MQ	SAINT PIERRE-MIQUELON
SUDAN	SUDAN
SURINAM	SURINAM
SWAZILND	SWAZILAND
SWEDEN	SWEDEN
SWTZRLND	SWITZERLAND
SYRIA	SYRIA
TANZANIA	TANZANIA
THAILAND	THAILAND
TIMOR	TIMOR
TOGO	TOGO
TONGA	TONGA
TRND THG	TRINIDAD AND TOBAGO
TUNISIA	TUNISIA
TURKEY	TURKEY
UGANDA	UGANDA
UN AR EM	UNITED ARAB EMIRATES
UN KNGDM	UNITED KINGDOM
UP VOLTA	UPPER VOLTA
URUGUAY	URUGUAY
US VG IS	VIRGIN ISLANDS, US
USA	UNITED STATES
USSR	USSR
VENEZUEL	VENEZUELA
W HMP NS	WESTERN HEMISPHERE NS
W SAMOA	WESTERN SAMOA
WINDW IS	WINDWARD ISLANDS
YEMEN AR	YEMEN ARAB REPUBLIC
YEMEN PR	YEMEN, PEOPLES REPUBLIC
YUGOSLAV	YUGOSLAVIA
ZAIRE	ZAIRE
ZAMBIA	ZAMBIA

2. Schematic Diagram of the WARP File

```
                        ┌─────────────┐
                        │    WARP     │
                        │  DATA BASE  │
                        └─────────────┘
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CATEGORY	POWERS REPRESENTED	TARGET AREAS

```
                     ┌─────────────────────┐
                     │ National            │
                     │ France              │
                     │ Germany             │
                     │ Japan               │
    ┌─────────┐      │ United Kingdom      │
    │ GENERAL │ ───► │ Russia              │
    └─────────┘      │ United States       │
                     │ (69 variables)      │
                     └─────────────────────┘

                     ┌─────────────────────┐
                     │ National            │
                     │ France              │
                     │ German              │
                     │ Japan               │      ┌──────────────┐
    ┌─────────┐      │ United Kingdom      │      │    WARP      │
    │  MONEY  │ ───► │ Russia              │ ───► │   COUNTRY    │
    └─────────┘      │ United States       │      │    LIST      │
                     │ (47 variables)      │      │   (195)      │
                     └─────────────────────┘      └──────────────┘

                     ┌─────────────────────┐
                     │ National            │
                     │ France              │
                     │ German              │
                     │ Japan               │
    ┌─────────┐      │ United Kingdom      │
    │ PEOPLE  │ ───► │ Russia              │
    └─────────┘      │ United States       │
                     │ (43 variables)      │
                     └─────────────────────┘

    ┌─────────┐      ┌─────────────────────┐      ┌──────────────┐
    │  TRADE  │ ───► │ United States       │ ───► │ TRADE ROUTES │
    └─────────┘      │ ( variables)        │      │    (65)      │
                     └─────────────────────┘      └──────────────┘
```

FOOTNOTES

[1]Stanford University, Department of Statistics, Technical Report no. 71, The Use of Faces to Represent Points In n-Dimensional Space Graphically, by Herman Chernoff, December, 1971.

[2]Orchestration Codebook, Center for Naval Analyses. Arlington, Va., August, 1976.

[3]J. L. Christensen and J. M. Pieper, World Analytic Research Project (WARP): Data Base Documentation and User's Guide, Washington D.C.: Air Force Data Services Center, 1976.

[4]Norman H. Nie, C. Hadlai Hull, Jean G. Jenkins, Karin Steinbrenner, and Dale h. Bent, SPSS: Statistical Package for the Social Sciences, Second Edition (New York: McGraw-Hill Book Company, 1975) p. 21-27.

[5]Orchestration Codebook.

[6]Christensen and Pieper, WARP.

[7]T. R. Gurr, Politimetrics: An Introduction to Quantitative Macro-Politics, (Englewood Cliffs: Prentice-Hall, Inc., 1972) p. 84-87.

[8]G. F. Lindsay, Unpublished lecture notes, Naval Postgraduate School, (OA4207 Scaling Techniques, Summer, 1976). Explanation of expotential smoothing and least squares technique equations.

[9]Gurr, Polimetrics, p. 108-111.

[10]Nie, et. al, SPSS, p. 181-189. Euqation for skewness:

$$\frac{\Sigma_{i=1}^{N} \left((X_i - \overline{X})/s \right)^3}{N}$$

equation for kurtosis (centralized);

$$\frac{\Sigma_{i=1}^{N} \left((X_i - \overline{X})/s \right)^4}{N}$$

[11]Nie, SPSS, p. 528-529, and Gurr, Polimetrics, p. 108.

[12] R. G. Sherwin, WEIS Project Final Report, (Los Angeles: University of Southern California Press, School of International Relations: 1973).

[13] Herman Chernoff, Personal communication (letter) of August 25, 1976.

[14] Chernoff, The Use of Faces--n-Dimensional Space.

[15] L. A. Bruckner, "The Looks of Some Companies Involved in Offshore Oil and Gas Leases, paper presented at the Annual Meeting of the American Statistical Association, Boston, Mass., August 22-26, 1976.

[16] Herman Chernoff, "The Use of Faces to Represent Points in k-Dimensional Space Graphically," Journal of the American Statistical Association, v. 68 (1973), p. 361-368.

[17] Bud Goode, Personal communication (letter) of September 7, 1976.

[18] Interview with Dr. C. M. Newton and Jerry Johnson, UCLA Health Sciences Computing Facility, Los Angeles, California, June, 1976.

[19] J. W. Rousuck, "Computer Faces That 'Talk'," The Sun Magazine, August 25, 1974, p. 12-13.

BIBLIOGRAPHY

Ackley, Richard T. "The Soviet Merchant Fleet," in Soviet Naval
    Influence: Domestic and Foreign Dimensions. Edited by Michael
    McGwire. New York: Praeger, Inc., 1976.

Berliner, Joseph S. Soviet Economic Aid: The New Aid and Trade Policy
    in Underdeveloped Countries. New York: Praeger, Inc., 1958.

Bruckner, Lawrence A. The Looks of Some Companies Involved in Offshore
    Oil and Gas Leases. Paper presented at the Annual Meeting of
    American Statistical Society Association, Boston, Mass., August 22-
    26, 1976. (LA-UR-76-462)

Bruckner, Lawrence A., Johnson, Myrle M., and Tietjen, Gary L.
    The Analysis of Lease, Production and Revenue Data from Offshore
    Oil and Gas Leases. Proceedings of the Second ERDA Statistical
    Symposium, Oak Ridge, Tenn., October 25-27, 1976. (LA-UR-76-1062)

Center for Naval Analysis. Orchestration Codebook. Arlington, Va.,
    August 1976.

Center for Naval Analysis, Professional Paper No. 155. Soviet Foreign
    Policy and Third World Nations. By Michael L. Squires. Arlington,
    Va., June 1976.

Central Intelligence Agency, Reference Aid CR CS 76-008. Chiefs of
    State and Cabinet Members of Foreign Governments. August 1976.

Central Intelligence Agency, Reference Aid A (CR) 75-45. Directory
    of Soviet Officials, Volume I: National Organizations. December
    1975.

Central Intelligence Agency, Research Aid A (ER) 75-65. Handbook of
    Economic Statistics 1975. August 1975.

Chernoff, Herman. Personal communication (letter) of August 25, 1976.

_____. "The Uses of Faces to Represent Points in k-Dimensional
    Space Graphically." Journal of the American Statistical Association
    v. 68:342 (June, 1973): 361ff..

Chernoff, Herman and Rizvi, M. Haseeb. "Effect on Classification Error
    of Random Permutations of Features in Representing Multivariate
    Data by Faces." Journal of the American Statistical Association
    v. 70:351 (September, 1975):548ff.

Christensen, John L. and Pieper, James M. Worldwide Analytic Research
    Project (WARP) Data Base Documentation and User's Guide. Air Force
    Data Services Center, October 13, 1976.

Daniel, Donald C. Navies as Instruments of Foreign Policy, USA/USSR. Paper presented at the International Studies Association Convention, St. Louis, Missouri, March 20, 1974.

Erlich, Alexander and Sonne, Christian R. "The Soviet Union: Economic Activity," in Africa and the Communist World. Edited by Zbigniew K. Brzezinski. Stanford, California: Stanford University Press.

Gnanadesikan, R. Methods for Statistical Data Analysis of Multivariate Observations. New York: John Wiley & Sons, 1977.

Goode, Bud. Personal communication (letter) of September 7, 1976.

Gurr, Ted Robert. Politimetrics: An Introduction to Quantitative Macro-politics. Englewood Cliffs, N.J.: Prentice-Hall, Inc. 1972.

Hahn, Walter F. and Cottrell, Alvin J. Soviet Shadow Over Africa. University of Miami, 1976.

Inter-University Consortium for Political Research. Data Available 1975-1976. Ann Arbor, Michigan: University of Michigan Press, 1976.

Jacob, Robert J. K., Egeth, Howard E., and Bevan, William. "The Face as a Data Display." Human Factors, 18(2) (1976):189-200.

Johnson, Robert R. Elementary Statistics, Second Edition. Belmont, California: Wadsworth Publishing Co., Inc. 1976.

Kautsky, John H. Communism and the Politics of Development: Persistent Myths and Changing Behavior. New York: John Wiley and Sons, Inc. 1968.

Kitchen, Helen. A Handbook of African Affairs. New York: Praeger, 1964.

Kulski, W. W. The Soviet Union in World Affairs: A Documented Analysis 1964-1972. Syracuse, N.Y.: Syracuse University Press, 1973.

Kurzman, Dan. Subversion of the Innocents: Patterns of Communist Penetration in Africa, the Middle East, and Asia. New York: Random House, 1963.

Lessing, Pieter. Africa's Red Harvest. New York: The John Day Co., 1962.

Legvold, Robert. Soviet Policy in West Africa. Cambridge, Mass.: Harvard University Press, 1970.

Naval Postgraduate School, W. R. Church Computer Center. Users Manual, Second Edition. Monterey, California: Naval Postgraduate School, November, 1974.

Nie, Norman H., Hull, C. Hadlai, Jenkins, Jean G., Steinbrenner, Karin and Bent, Dale H. SPSS: Statistical Package for the Social Sciences, Second Edition. New York: McGraw-Hill, 1975.

Oliver, Roland and Atmore, Anthony. Africa Since 1800. Cambridge: At the University Press, 1967.

Rousuck, J. Wynn. "Computer Faces That 'Talk'." The Sun Magazine. August 25, 1974, 12-13.

Sawyer, Carole A. Communist Trade with Developing Countries: 1955-65. New York: Praeger, 1966.

Schatten, Fritz. Communism in Africa. New York: Praeger, 1966.

Smith, Clyde A. "Constraints of Naval Geography on Soviet Naval Power." Naval War College Review Sep-Oct. 1974. p. 46-57.

Solodovnikov, V. Soviet View of Neocolonialism as Threat to Africa. Joint Publications Research Service 47545, Washington, D. C. February 28, 1969.

Stanford University, Department of Statistics, Technical Report No. 71. The Use of Faces to Represent Points in n-Dimensional Space Graphically. By Herman Chernoff. December 5, 1971.

Strong, John W., Editor. The Soviet Union Under Brezhnev and Kosygin: The Transition Years. New York: Van Nostrand Reinhold Company, 1971.

Thornton, Thomas Perry, Editor. The Third World in Soviet Perspective: Studies by Soviet Writers on the Developing Areas. Princeton, N.J.: Princeton University Press, 1964.

U. S. Department of State, Research Memorandum RSB-80. Communist Governments and Developing Nations: Economic Aid and Trade. By Thomas L. Hughes. July 21, 1967.

U.S. Department of State, Research Study INR RS-20. Communist States and Developing Countries: Aid and Trade in 1973. October 10, 1974.

U.S. Department of State, Research Study Report No. 298. Communist States and Developing Countries: Aid and Trade in 1974. January 27, 1976.

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This paper is an application of the graphical representation of k-dimensional data technique developed by Professor Herman Chernoff. It is written for the intended use of foreign policy and international relations analysts as a statistical tool in analyzing and presenting complex Soviet foreign policy phenomena. It discusses building a computer base data file from existing sources, purpose and techniques for data modifications and transformations, and methods for selecting variables for the research problem. Soviet foreign policy acts in twenty-five Sub-Saharan African countries for 1964 through 1975 are then represented and analyzed in ten sets of FACES. Other applications of the FACES methodology are reviewed and recommendations are made for further modifications and applications of the methodology in the area of foreign policy studies.